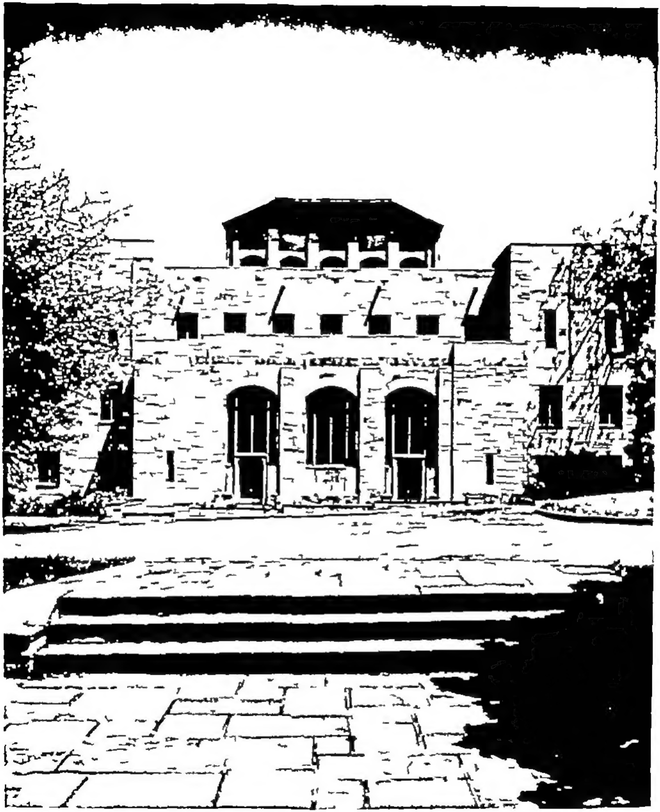

THOMAS HENRY BOWLES MEMORIAL
of the
CHILDREN'S HOSPITAL SCHOOL

MUSCLES

TESTING AND FUNCTION

By

HENRY O. KENDALL

and

FLORENCE P. KENDALL

Physical Therapy Department
Children's Hospital School
Baltimore, Maryland

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FOREWORD

For over twenty five years we have been fortunate in having Henry O Kendall in charge of the Physiotherapy Department of the Children's Hospital School. During that time not only has a great volume of clinical work been splendidly carried on but also due to the team work of Henry Kendall and his wife Florence Peterson Kendall a valuable series of original scientific papers and treatises has appeared in which we were proud to share by observation criticism and the writing of brief forewords So it was that when they proposed to concentrate their wide experience their technical skill and their critical judgment in one big volume to give a thorough exposition of the methods and results of neuromuscular physical examination we were delighted Now that it is completed we feel they have succeeded admirably in their difficult task and that the book with its text charts and illustrations has made the difficult techniques clear and shown the way to correlate and evaluate the information obtained. Although a textbook containing necessarily established facts and methods it presents them more clearly and graphically than ever heretofore and in addition it contains much that is entirely new and extremely valuable especially the diagnostic nerve charts for the peripheral nerves We take pleasure and pride in commending to the medical world this book entitled *Muscles Testing and Function* by Henry O and Florence P Kendall

George E Bennett *Emeritus Adjunct Professor of Orthopedic Surgery*

Robert W Johnson *Adjunct Professor of Orthopedic Surgery*

Johns Hopkins Medical School

PREFACE

Muscle testing procedures are an integral part of physical diagnosis and form the basis for determining individual needs in relation to specific forms of treatment in muscular and neuromuscular disorders A detailed account of the testing procedures and of the functional significance of muscle weakness and contracture is embodied in this text

We believe this book will be particularly useful to physicians surgeons physical therapists occupational therapists and physical educators There has been an insistent demand for a comprehensive book on muscle testing by people in these various fields

We have had the opportunity to do detailed muscle testing on several thousand patients both paralytic and non-paralytic In addition muscle tests and postural examinations have been done on approximately one thousand so-called normal individuals of various age groups for the purpose of research The information obtained through experience in muscle testing has proved indispensable to us in further analyzing problems relating to muscle function. We feel it is a privilege and a responsibility to make available to others the information thus acquired

We do not aim to set forth new theories nor outline new systems of procedure Our purpose is to interpret existing facts in the light of our experience and study We have accepted only such procedures as stand the test of detailed analyses on the basis of known anatomical facts

Dr Robert W Lovett and his co-workers laid the firm foundation for much of the muscle testing done today We do not seek to have this text supplant the earlier work but we do seek to enlarge the scope of muscle testing and help clarify many of the problems that have continued to exist

This book presents muscle testing in a simple direct manner which should enable the reader to clearly visualize the procedures involved in testing grading and recording muscle strength It is written in text book style and is extensively illustrated The first chapter which deals with general procedures is presented in non technical terms The remaining chapters which consist of specific test procedures require the use of anatomical terms for accuracy and brevity

Extensive investigation has been done in the preparation of the DIAGNOSTIC CHARTS FOR NERVE LESIONS (pp 32 and 34) and the SPINAL MOTOR NERVE AND ANATOMICAL MOTOR POINT CHARTS (pp 33 and 35) The authors have made every effort to extract the pertinent information from authoritative works on anatomy and neurology Texts which have been consulted include the following Grant Sabotta Cunningham, Gray Morris Quain, Spalteholz Foerster and Haymaker and Woodhall The spinal segment nerve supply as charted is a compilation from texts by the last six above named authorities The appendix which lists muscles grouped according to joint action and their origins and insertions has been compiled mainly from *Gray's Anatomy*

U S Public Health Bulletin no 242 (April 1938) written by the authors has been used rather extensively Chapter IV of this Bulletin has been revised, and with additions constitutes Chapter V of this text

The similarity which abdominal muscle tests bear to those described in *Physical Therapy for Lower Extremity Amputees* (War Department Technical Manual 8-293) is accounted for by the fact that the authors of this text assisted in the preparation of the manual

This book as many others has come into existence through the inspiration cooperation and assistance of many people

We thank the medical directors and staff and the co-workers in the physical therapy department at the Children's Hospital School for their encouragement in study and research their interest and assistance in the project of writing this book and for their constructive criticism in reviewing the subject matter of this

text Williams & Wilkins the publishers have given us valuable aid and advice For the splendid photography we are indebted to Charles C Krause Jr In the test pictures every effort has been made to show the muscle the direction of movement and to indicate the place and direction of the examiner's pressure These requirements have been met only because of the photographer's patience skill, and meticulous attention to detail. We appreciate too the assistance of all who acted as subjects for the photographs The anatomical drawings have been made by William E Loechel whose ability and interest have made it possible to obtain the detailed accuracy in the illustrations

To the patients and friends who created a fund which enabled the undertaking of this project, we wish to express our sincere appreciation. The extent of illustrative material bears testimony of their generosity but the inspiration that the friends imparted cannot be bound between the covers of a book.

For the facilities provided for Physical Therapy at the Children's Hospital School, we are indebted to Louise Cunningham Bowles who gave the Thomas Henry Bowles Memorial Building It is to Mrs Bowles that we dedicate this book

We wish to thank all others who have assisted us and were it possible we would acknowledge each individually

HENRY O KENDALL
FLORENCE P KENDALL

CONTENTS

CHAPTER I

FUNDAMENTAL PRINCIPLES IN MANUAL MUSCLE TESTING

Muscle testing is an integral part of physical iagnosis and is an important factor in prog osis and treatment of muscular disorders

As a form of physical diagnosis it supplies ssential information that cannot be obtained y other diagnostic procedures It is important n differential diagnosis

A distinguishing feature in many neuromuscular disorders is the characteristic muscle weakness Some conditions are characterized by the lack of a pattern of weakness some by symmetry of the weakness and others by the definite pattern of muscle involvement

Muscle testing is an aid in determining the site or level of a peripheral nerve lesion, since only the muscles deriving innervation from the nerve branches distal to the lesion will show weakness

The rate and degree of return of muscle power as shown by the charting of repeated examin ations furnishes an index to the prognosis The physician may be guided by the muscle examination findings in prescribing and altering treatment The evaluation of muscle strength may prove useful in making a decision regarding a muscle or fascial transplant

Muscle testing is a procedure which depends on the knowledge experience and skill of the examiner It demands rigorous attention to every detail that might affect its accuracy Failure to take into consideration apparently in significant factors may alter test results enough to make them misleading and inaccurate test results will only confuse while they appear to enlighten

The examiner has a great responsibility not to betray by carelessness or lack of skill, the confidence that others rightfully place in muscle testing procedures Test results are only as use ful as they are accurate

Muscle testing requires both a comprehensive and detailed understanding of anatomy and muscle function Specifically this should in clude a knowledge of the origin and insertion of muscles their anatomical synergistic and antagonistic actions and their role in fixation In addition it requires the ability to locate the muscle belly to distinguish between normal and atrophied contour and to recognize abnormal ities in position and general appearance of the part

Muscle testing consists of two fundamental components (1) Test performance and (2) evaluation of the muscle strength Anyone who is sure of the exact action of muscles can learn in a relatively short time how to obtain the actual test performance from a patient Expe rience is necessary however to detect the sub stitution movements that occur whenever spotty weakness exists and practice is necessary to acquire skill in accurate grading of muscle strength

Continuing efforts will be made to devise a mechanical substitute for manual muscle test ing Technically it may not be too difficult to measure objectively the strength of a muscle But it is difficult to conceive of a machine that can substitute for the examiner in positioning the part directing pressure and detecting substitution

In manual muscle testing muscle grades ex press objectively the examiner's evaluation of the functional strength of the muscle Muscle grading can be considered only a functional eval uation (that is an estimate of the amount of work that the muscle can accomplish) There are so many factors involved in the picture of weakness and return of strength that the strength grade cannot possibly be an indication of any single factor Weakness may be due to nerve involvement disuse atrophy stretch weakness pain or fatigue Return of muscle strength may be due to recovery following the disease process return of nerve impulse as may follow nerve suture hypertrophy of unaffected muscle fibers muscular development resulting

from exercises to overcome disuse atrophy or return of strength after stretch and strain have been relieved Muscle grades are not intended to represent a direct measure of the pathology though the degree of functional strength bears a definite relationship to the extent and degree of such pathology In pathological lesions early examination findings are more nearly an index of the degree of involvement than subsequent examination findings when superimposed factors enter into the picture

Detailed grading of muscle strength is more important in relation to prognosis than to diagnosis Diagnosis of the extent of involvement can be made by such simple grading as zero weak normal More detailed evaluation however permits a more specific and accurate measure of the degree of involvement In repeated examinations the rate and degree of return of muscle strength can be determined only on the basis of careful grading Prognosis is judged largely by rate of return of muscle power that is the degree of improvement in relation to the time since onset A muscle might be 'weak' for months but a careful recording might show it had progressed from 10% to 60% during that period

The muscle testing described in this book is directed toward examination of individual muscles in so far as is practical Anyone in the field of muscle testing recognizes the overlap of muscle actions as well as the interdependence of muscles in movement Such close relationship in muscle function need not rule out the possibility or the practicability of testing for individual muscles. There are no two muscles in the body that have exactly the same function When any one muscle is paralyzed, some exact movement is lost or stability of a part is impaired If the test position cannot be held or the test movement cannot be performed because of the paralysis or weakness of the one muscle to which the test is ascribed then we have individual muscle testing in a practical sense of the word (See fig 1)

There is a remarkable accommodation by some muscles for the loss of function of other muscles. A substitution may develop which almost obscures the original loss but in early examination of affected parts it should not be difficult to detect the impairment

In neuro-muscular diagnostic work individual muscle testing is essential Neuro-pathological conditions are not selective in causing loss of function of muscles grouped according to joint action In peripheral nerve and nerve root lesions the loss of function may follow the pattern of peripheral nerve involvement partial or complete involvement of one or more cords of the plexus or of the spinal nerve root Paralysis or weakness of muscles in anterior poliomyelitis does not appear to follow any particular pattern Group tests may be used as functional tests but should be referred to as such

In describing muscles in relation to joint action much emphasis has been placed by various kinesiologists on naming the prime mover of such group action One might rather be concerned with the fact that every muscle is a prime mover in some specific action. In the search for that action one is led into the field of individual muscle testing

The word 'isolation' has been used in connection with testing for separate or individual muscle action Technically it is well to limit the use of the word 'isolation' to a comparatively few muscle tests. Isolation is defined (Funk & Wagnalls) as 'To place in a detached or insulated position To obtain in a free or uncombined state' The first usage does not apply in muscle testing but since some tests obtain the action of muscles in an 'uncombined state' the second usage may apply One does not separate the muscles but does separate the actions of the muscles in such a way that the strength or lack of strength of a particular muscle can be determined.

The action of such muscles as flexor digitorum profundus and flexor digitorum longus can be 'isolated' in the flexion tests of the distal phalanges of the fingers and toes respectively because no other muscles cross the joint to assist in the flexion action

The action of various other muscles can be differentiated to such an extent that the test becomes one of relatively isolated function When

a one-joint and a two-joint muscle act together in a movement there can be isolation of the action of one from that of the other by placing the two-joint muscle at a mechanical disadvantage In all muscles there is a point of maximum strength in the arc of movement Beyond

FIG 1

The above figure illustrates the test of the psoas major muscle The subject is an athlete in whom muscle action is particularly well demonstrated. As the photograph clearly shows, the quadriceps (rectus femoris in the hip action) sartorius and the adductors are all assisting in holding the hip flexion position. Yet the line of pull and the direction of pressure place emphasis on the action of the right psoas major and the test disclosed a weakness of this muscle (The origin insertion and line of pull of the muscle fibers is illustrated in fig 97b) The weakness of the right psoas was sufficient to account for the deviation of the lumbar spine away from the side of weakness. (See fig 98.)

that point in either direction a muscle loses efficiency to the extent that it is at a definite mechanical disadvantage when stretched or when placed in a position of maximum relaxation When a two-joint muscle has completed the full range of motion of one joint it has much less power to shorten further in assisting completion of action on the second joint For example hamstring action is eliminated almost entirely by flexing the knee in the hip extension test for the gluteus maximus (See fig 2)

The isolation of the supinator muscle is made possible by placing the biceps on a stretch (by backward extension of the shoulder joint and extension of the elbow joint) or by placing the biceps in a position of maximum relaxation (by elbow flexion and flexion of the shoulder to shoulder level) (See figs 37 and 38)

The order of the tests as they appear in this text is of no particular significance except that muscles which are closely related in position or action tend to appear in sequence in order to distinguish test differences

For the convenience of the reader a comprehensive table of muscle origins and insertions has been compiled as an Appendix The action of a muscle is dependent upon its attachments and a review of these may clear up problems which arise in regard to testing The close relationship of muscles determines their action in substitution assistance and stabilization during tests of individual muscles The grouping of muscles according to joint action in the Appendix has been done to aid the examiner in understanding the allied action of muscles

Though most muscle testing is applied to patients with varying degrees of weakness or paralysis the authors have chosen to use normal subjects for the muscle test photographs This has been done in an effort to demonstrate normal muscle function and to show the contour and location of muscles in test action

Terms Used in the Description of Muscle Tests

Each of the extremity muscle tests described in this text (Chapters III and IV) is outlined

according to the following topics 'patient' fixation' 'test and 'pressure'

These topics are discussed in detail in order to point out their particular significance in relation to accurate muscle testing

PATIENT In the description of each test the word 'patient is followed by specifying the position in which the patient is placed in order to best accomplish the desired test The position of the patient is important in relation to the test in two respects (1) The position of the body should permit function against gravity for all muscles in which gravity is a factor in grading and (2) the body should be in such a position that parts not being tested will be held as firm and stable as possible The examiner can stabilize the part proximal to the tested part in tests of the toe finger foot and wrist muscles but in all other tests the body weight should h stabilize the proximal part In most tests lying position offers the best fixation 1 sitting position tests which involve forward backward positions of the arms may requ some fixation by the examiner in addition to stability afforded by the weight of the bo The standing position necessitates action of many muscles to maintain the body uprig

FIG 2. Isolation of gluteus maximus from hamstring action in hip extension by the knee flexion positi

that no test in standing can be consider limited to a single muscle or even to a sing group of muscles

In all muscle testing the comfort of the p tient and the intelligent handling of the affect muscles are to be considered before any rules principles in regard to test position. Insistu on an anti-gravity position may result in utter absurd handling of the patient Side lying po

tions which offer the best test position for several muscles may be uncomfortable and result in strain of other muscles in early poliomyelitis cases A good examiner should be able to obtain a satisfactory estimate of strength regardless of the position of the patient

FIXATION Numerous factors are considered under the heading of fixation In general fixation refers to the firmness or stability of the body necessary to insure an accurate test of any specific muscle or muscle group The part proximal to the tested part must be stable Stabilization (holding steady) support (holding up) and counter pressure (equal and opposite pressure) are all included under the word 'fixation which implies holding firm

Fixation depends to a great extent on the firmness of the *examining table* In a sense the table offers much of the necessary support Testing and grading of strength will not be accurate if the patient lies on a soft bed that gives as the examiner applies pressure

Body weight may furnish the necessary fixation for stabilizing the part proximal to the tested part Because the weight of the body is an important factor in offering stability the horizontal position whether supine prone or side-lying tends to offer best fixation for most tests

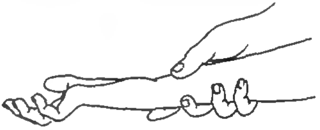
The *examiner* may stabilize the part proximal *to the tested part in such a way as to insure an* accurate test Sometimes this is accomplished by holding or supporting the part as in the fixation of the lower leg for tests involving the ankle motion It may be accomplished by holding the body firmly down on the table so that the weight of the tested part plus the examiner's pressure against it do not displace the weight of the proximal part In rotation tests the examiner always applies counter pressure to insure exact test performance (See Arm Rotation Tests pp 108 and 110 and Leg Rotation Tests pp 170 and 172)

In some tests *muscles* furnish direct fixation for the accomplishment of the test

The muscles which stabilize the scapula and the pelvis during arm and leg movements are referred to as fixation muscles. They do not enter directly into the movement but do stabilize the movable scapula or pelvis to the fixed trunk and make it possible for the tested muscle to have a firm origin from which to pull In the same way the anterior abdominal muscles must fix the thorax as the anterior neck flexors act to lift the head forward in flexion

Muscles which have an antagonistic action may give fixation in such a way as to prevent abnormal joint movements This principle is illustrated by the lumbricales fixation in finger extension Normally lumbricales restrict hyperextension at the metacarpo-phalangeal joints In the presence of weak lumbricales the pull of a strong extensor digitorum communis will result in hyperextension of these joints and flexion of the interphalangeal joints If the examiner cups the palm giving the lumbricales fixation these movements do not occur and the fingers may be extended normally (See fig 3)

When the fixation muscles are too weak or too strong the examiner by assisting or restricting movement of the part can simulate the normal stabilization The examiner must be able to



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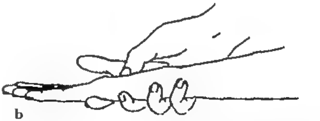

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FIG 3

(a) Hyperextension of the metacarpo-phalangeal joints due to weakness of the lumbricales prevents normal function of the extensor digitorum communis in extending the interphalangeal joints.

(b) When the examiner cups the palm offering fixation that normally is afforded by the lumbricales, a strong extensor communis will extend the fingers.

differentiate between the normal action of these muscles in fixation and the abnormal actions which occur when muscle imbalance is present.

Muscles may furnish indirect fixation in many test movements. Such fixation is a complex problem in testing and cannot be dealt with by general or specific rules. The influence of weakness of the indirect fixation muscles is mentioned in connection with some tests. (See Gluteus Maximus, p. 181.)

TEST. The word "test" is followed by a description of the muscle test action for the given muscle. The wording is such that it may apply either to the *Test Position* or the *Test Movement* depending upon whether one or both are employed in the examination. Test position is the position in which the part of the body is placed by the examiner and held (if possible) by the patient. (The photograph of each muscle test [Chapters III and IV] shows the test position.) Test movement is movement of the part through a specified arc of motion and in a specified direction.

The use of test position lends speed and accuracy to muscle examinations. When test position is used in the initial test of a muscle exactness is obtained by avoiding the necessity for the patient to follow a verbal description of a movement. Accuracy depends to a great extent on the ability to rule out or at least to detect substitution movements. Such movements occur more readily and are more difficult to detect in test movement than in test position.

The use of test position is a time-saving device in the lengthy procedure of testing and grading muscle strength. As each muscle is tested the ability or inability to hold the part is at once established. Thus the grade is either at or below 50%. If the test position can be held the examiner applies pressure in order to determine the degree of muscle strength above 50%. (See Pressure and Grading, pp. 7 and 9.)

If the subject cannot hold the test position the part will drop either suddenly or gradually or will shift in such a way that substitution is obvious. When a muscle fails to hold, it is necessary to have the patient attempt the test movement through the desired range of motion. The examiner first demonstrates the test passively, then the patient is asked to attempt the movement.

A one-joint muscle is frequently required to hold the position of maximum contraction in the test. A muscle which crosses two or more joints is not required to complete the range of motion in all joints. The attempt to complete the range of motion of all joints would place the muscle in a mechanically inefficient test position due to the extreme contraction necessary in the shortened position of the muscle. Completion of joint action of all in a series of joints is normally restricted by opposing long muscles. These opposing muscles should not be unduly stretched over two or more joints and nature has provided such a safeguard by the synergic action of other muscles.

Synergic muscles (as defined by Gray) are those which act to inhibit movements not required. The authors feel that synergic action is of considerably greater significance than this definition implies. The common example of the synergic wrist extensor action in relation to finger flexion may be used to illustrate. If an effort is made to flex the fingers with the wrist in flexion, there is little strength in the finger flexion movement. A considerable tension is placed on the extensor communis digitorum. If strong pressure is applied against the finger flexors and the subject strains to hold the position, a feeling of undue contraction in the muscle may result. The action of the synergic muscles (by holding the wrist in extension) guards against injury to the opponent and against both injury and loss of efficiency in the particular action of the muscle involved.

In testing muscles one uses the principle of stretch or position of maximal relaxation as a basis for differentiation between the action of a one-joint muscle and a two (or more) joint muscle which crosses the same joint (see p. 2). Such testing must be done with the understanding that positions for differentiation should not involve stretch to a point of harm nor contraction (in a shortened position) to the point that the muscle contracts excessively (as denoted by the phenomenon of muscle "cramp").

Muscle weakness must be distinguished from restriction of range of motion Frequently a muscle does not complete the normal range of joint motion It may be that the muscle is too weak to complete the movement or it may be that the range of motion is restricted due to contracture of muscles capsule or ligamentous structures. The examiner should passively carry the part through the range of motion to determine whether any restriction exists. If no restriction is present failure to perform the muscle test may be interpreted as weakness If the joint structures or opposing muscles restrict motion the test will not be completely accurate but a good estimate of the muscle strength can be obtained Joint tightness or restriction due to opposing muscle tightness is denoted by recording the grade of muscle strength in parentheses For example (50%) indicates that the muscle can move the part to completion of the existing range of motion or can hold the part in a modified test position which represents completion of the limited arc of motion

The degree of actual muscle weakness is difficult to judge in cases of relaxed unstable joints Functionally the muscle is weak and must be so graded but it may be extremely important from the standpoint of treatment to detect the good contraction power of a muscle which appears extremely weak because of joint instability Instances are not uncommon in which the deltoid muscle shows a "fullness of contraction power throughout the muscle belly and yet cannot begin to lift the weight of the arm Such cases should be splinted with the express purpose of allowing the joint structures to shorten to their normal position Muscle examinations should detect the presence of such superimposed factors as demonstrated in relaxed joints The patient may be deprived of adequate follow-up treatment by the failure to distinguish between real and apparent weakness

PRESSURE The word 'pressure is used throughout the test descriptions in place of what formerly has been called resistance Resistance is defined (Funk & Wagnalls) as any force tending to hinder motion Technically one does not apply resistance in muscle testing Even though a test movement is performed by a muscle which can act against gravity resistance is not used but the subject is allowed to complete the arc of motion before any opposing force is applied by the examiner Gravity and table friction do offer resistance to test movements but the examiner does not offer manual resistance

Pressure ' is used to denote the outside force applied by the examiner to determine the strength of the muscle holding in test position In the outline of the muscle tests, pressure is described in two parts 'Against and 'in the direction of' Against ' refers to the position of the examiner's hand in relation to the patient and "in the direction of" describes the direction of the application of force directly opposite the line of pull of the muscle or its tendon. The place where pressure is applied and the direction of pressure are as important to the accuracy of the testing as is the test position itself

In some of the muscle test illustrations the examiner's hand has been held extended for the purpose of indicating (photographically) the direction of pressure which is perpendicular to the palmar surface of the hand It is not intended that such a hand position be imitated in the actual muscle testing

The place at which pressure is applied bears relationship to the insertion of the muscle to the joints involved and to the principle of employing leverage in testing In general pressure is applied near the distal end of the part on which the muscle is inserted The exceptions to this general rule occur in relation to muscles in which a longer leverage is required than that afforded by the adjacent part (For examples see Gluteus Medius Test p 178 and Middle Trapezius Test p 110)

The principle of leverage must be utilized in muscle testing In many instances test results might be an indication of the strength of the examiner rather than of the patient if the examiner did not have the advantage of leverage

As the *direction* of the pressure is an important part of accurate test performance the *amount* of pressure is the determining factor in grading

above 50% (or Fair). The application of pressure is discussed below under Grading (p 9)

SUBSTITUTION

When a muscle or muscle group attempts to compensate for the lack of function of a weak or paralyzed muscle the result is a substitution movement. Muscles which normally act together in joint movements are in position to act in substitution.

The following may enter into substitution action:

Muscles which act as synergists
Muscles which assist in the joint action
Muscles which act in direct fixation

The overlap between substitution and fixation may be indicated as follows:

Substitution { Synergic Muscles
Assisting Muscles
Direct Fixation Muscles
Indirect Fixation Muscles } Fixation
Antagonistic Muscles

Substitution by direct fixation muscles occurs specifically in relation to movements of the shoulder joint, hip joint, and neck.

Action of the scapular muscles may be substituted for shoulder joint muscles, and muscles which move the pelvis may substitute for hip joint muscles. (See fig 4.) A patient may use the abdominal muscles to depress the thorax, flexing the upper trunk to raise the shoulders up from the table. As he does so, the head is lifted from the table.

The result is not the true action required in the test and an experienced examiner will detect these substitutions readily. When *test position* is employed instead of *test movement* an examiner though inexperienced can detect the sudden shift of the body which results from the effort to compensate for the muscle weakness.

Synergists may substitute by producing movement which resembles the test movement. If finger flexors are weak, the synergic action of the wrist extensors may produce passive finger flexion.

Substitution by a muscle which normally assists another in a specific joint action results in

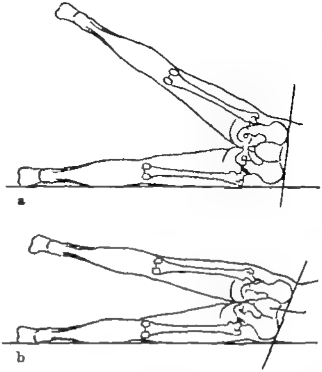


FIG 4

(a) True abduction of the leg is accomplished by the hip abductors with the normal fixation by the lateral abdominal muscles.

(b) Apparent abduction of the leg may be accomplished, when hip abductors are weak, by the substitution action of the lateral abdominals. The pelvis is hiked up laterally and the leg is lifted from the table, but there is no true hip joint abduction.

either (1) Movement of the part in the direction of the strongest pull of the assisting muscle or (2) shift of the part in such a way as to favor the pull of the assisting muscle.

When there is evidence of restriction of joint motion due to contracted muscles, a movement to relieve tension of a tight muscle may appear similar to a movement of substitution. (See description of substitution action in Hamstring Test, p 155.)

For accurate muscle examinations no substitution should be permitted, that is, the position or movement described as the test should be done without shifting the body or turning the part to allow other muscles to perform the movement for the weak or paralyzed muscle. If the examiner knows normal function and realizes the

ease with which a normal muscle performs the exact test movement he will recognize substitution movements

Muscle Weakness Shortness and Contracture

Included with the description of many of the muscles in this text is a discussion regarding loss of motion or mal position which results from weakness shortness or contracture. Weakness is used as an over-all term covering the range from zero to 50% (fair) muscle strength in non weight bearing muscles. 60% or 70% muscles should not cause appreciable loss of movement but will result in mal position of the part if such weakness is present in major weight-bearing muscles

A weakness will result in loss of movement in the sense that the muscle cannot move the part through arc of motion decreasing the distance between the origin and insertion. A contracture or shortness will result in loss of motion in the sense that the muscle cannot be elongated through its full range of motion, either passively or by the opposing muscle. The words contracture and shortness have been used to distinguish between an almost complete loss of range of motion as denoted by "contracture" and a partial loss of range of motion as denoted by "shortness." (The word "tightness" is used inter-changeably with the word "shortness.")

Both weakness and contracture will result in faulty alignment a weakness permitting a position of deformity and a contracture creating or holding a position of deformity. A muscle shortness will frequently cause a postural deviation

In some instances a fixed deformity does not occur as a result of weakness unless muscle contracture develops in muscles opposing the weaker group. In the wrist for example a fixed deformity will not develop as a result of wrist extensor weakness unless the opposing flexors contract to hold the position of wrist flexion. In many parts of the body however deformities will develop as a result of the weakness even though the opposing muscles do not become contracted because gravity and body weight exist as the opposing force. A kyphosis of the upper back will result from upper back muscle weakness whether the anterior trunk muscles become contracted or not. A position of pronation of the foot will become fixed if the inverters are weak because the body weight in standing will distort the bony alignment. The alignment will be distorted even further if the opposing peroneal muscles become contracted

A weak muscle is easily subjected to stretch and strain by overloading or over-exertion in exercise. A muscle that has developed a shortness or contracture as a result of weakness in the opposing muscles usually is an abnormally strong muscle. Recognition of this abnormally strong pull in the muscle is important in relation to treatment because stretching of the muscle is indicated while strengthening exercises are not

The muscle problem and treatment indications are quite different in respect to the muscle contracture that develops secondary to joint stiffness. In cases of joint stiffness the muscle develops an adaptive shortening. With complete loss of joint motion the muscle may show disuse atrophy from lack of exercise.

Grading

Dr Robert W Lovett introduced a method of muscle testing using gravity resistance as an objective measure for grading muscle strength. A description of muscle grading based on the Lovett system and published in 1932 listed the following

Gone—no contraction felt
Trace—muscle can be felt to tighten but cannot produce movement
Poor—produces movement with gravity eliminated but cannot function against gravity
Fair—can raise part against gravity
Good—can raise part against outside resistance as well as against gravity
Normal—can overcome a greater amount of resistance than a good muscle *

*Legg, A. T Physical Therapy in Infantile Paralysis from Principles and Practice of Physical Therapy Vol. II edited by Mock. Hagerstown, Md., W F Prior Co., Inc 1932, p. 45.

The movement and weight factors set forth in this system form the basis of most present-day muscle grading though symbols vary in the use of the words letters or numerals

The principles of grading as presented in this text are not a major deviation from these earlier principles but an attempt is made to analyze muscle grading more fully than has been done previously Some practical revisions and amendments to the generally accepted rules of grading are offered

THE GRAVITY FACTOR IN GRADING The gravity factor is not employed in the tests of some muscles because it is impractical A careful analysis of all tests shows to what degree it should be employed It need not be considered in tests of finger and toe muscles From a mechanical standpoint this is true because the weight of the part is so small in comparison with the strength of the muscle that the effect of gravity is unimportant

Reference has been made in the literature* to the fact that the use of anti-gravity position is not essential in testing foot and hand muscles but to date there has been no practical application of the principle put into a *key to grading*

The supinators and pronators of the forearm may also be tested without regard to the gravity factor Their range of motion is such that if the initial position is anti-gravity the end position is with gravity *Finger and toe muscles* and forearm rotators comprise approximately 40% of the extremity tests described. Grading of these muscles is based on the arc of motion factor and completion of arc is graded 50%

Tests of facial muscles involve neither gravity nor arc of motion factors (Grading these muscles is explained in Chapter VI)

In tests of the rhomboids middle and lower trapezius serratus anterior and latissimus dorsi there is a partial use of the gravity factor

Gravity remains an important factor in the grading of the large muscles of the extremities The ability to hold the anti-gravity test position or the ability to perform the anti-gravity arc of motion constitutes the grade of 50% for the *following wrist elbow shoulder neck, ankle* knee and hip (Back and abdominal muscle tests use the gravity factor but not on the same basis as do the extremity tests Grading of these muscles is described in Chapter V)

Muscles are divided into two classes for the purpose of grading In the following key to grading Class I represents the muscles in which the gravity factor is not involved Class II the muscles in which grading depends on the gravity factor

ANALYSIS OF KEY TO MUSCLE GRADING The following chart is quite self-explanatory but various deviations from the customary procedures of grading need to be explained Each section needs a careful analysis

Zero 5% and 10% grading depends on palpation. For that reason, in certain muscles which cannot be adequately palpated the grade should be recorded with a question mark to indicate that the examiner cannot be certain of either the absence of power or the presence of a trace of power The following muscles are included with those difficult to palpate ilio-psoas quadratus lumborum, pronator quadratus and some intrinsic hand and foot muscles It might be difficult to palpate for many other weak muscles on an obese individual

20% and 30% grades in Class I muscles are based on the amount of movement of the part that the muscle can produce The partial arc of movement may be at the beginning of the arc as is usually seen in finger flexors or may be present about the center of the arc of motion as may be seen in elbow flexors The angle at *which movement is initiated is not a matter of* concern in grading except that the examiner should be sure that the movement starts from a relaxed position If the part is carried to the beginning of the arc of motion and a slight tension put on the muscle there may be a springing back to position which can be confused with active movement

*Practical Suggestions on Poliomyelitis (p. 51) A digest for use in connection with the Exhibit on Poliomyelitis Scientific Exhibit, Milwaukee Session, 1933. (By Special Committee on Poliomyelitis)

KEY TO MUSCLE GRADING

Class I Finger and toe muscles, forearm supinators and pronators	Grade	Class II Wrist, elbow, shoulder, ankle, knee, hip, and neck muscles	
No contraction felt in the muscle No movement of the part	0	No contraction felt in the muscle No movement of the part	The gravity eliminated position is recommended for testing weak adductors and abductors of the hip, and flexors and extensors of the elbow. When GE (gravity eliminated) position is used, grading is modified as follows:
In muscles that can be seen or palpated, a feeble contraction may be felt in the belly of the muscle, or the tendon may become prominent during muscle contraction. No apparent movement of the part.	5% & 10%	In muscles that can be seen or palpated, a feeble contraction may be felt in the belly of the muscle, or the tendon may become prominent during the muscle contraction. No apparent movement of the part.	
The muscle moves the part through a visible arc of motion Small arc—20% Moderate arc—30%	20% & 30%	An estimate of the amount of work done by the patient in assisting the examiner lift the weight of the part during the test movement against gravity. A 20% muscle requires moderate assistance by the examiner, a 30% muscle requires slight assistance by the examiner.	Small arc— 20% GE Moderate arc— 30% GE Almost complete arc— 40% GE Complete arc— 50% GE
The muscle moves the part through almost complete arc of motion	40%	When the muscle attempts to hold the test position against gravity there is a very gradual release showing inability to hold the antigravity position or (Quadriceps, hip rotators, and deltoid in the sitting position, and triceps and arm rotators in the prone position may be graded 40% if:) The muscle moves the part through the antigravity arc of motion almost to completion.	Complete arc plus minimum pressure 60% GE, 70% GE
The muscle moves the part through complete arc of motion or The muscle holds the test position.	50%	The muscle holds the anti-gravity test position or The muscle moves the part through the anti-gravity arc of motion to completion	Complete arc plus moderate pressure 80% GE
The muscle moves the part through complete arc of motion and holds the completed position against minimum pressure or The muscle holds the test position against minimum pressure	60% & 70%	The muscle holds the anti gravity test position against minimum pressure or The muscle moves the part through the anti-gravity arc of motion and holds the completed position against minimum pressure	
Same as above, against medium pressure	80% & 90%	Same as above, against medium pressure	
Same as above, against maximum pressure	100%	Same as above, against maximum pressure	

20% and 30% grading in Class II muscles is the most variable both in the manner of testing and in that of recording. Either the assisted test movement against gravity or the test movement in a gravity eliminated position may be used. But in this text the use of the gravity eliminated position is recommended for only a few tests.

Turning a patient from the anti-gravity test position of a muscle into a gravity-eliminated position for the purpose of obtaining an objective grade of "poor" (20% to 30%) has been an accepted procedure in most muscle testing. However, in the practice of muscle testing frequent change of the patient's position or repetition of the test in various positions is fatiguing to the patient and time consuming for the examiner.

Except for the few muscles which are discussed below, it is recommended that the grades between 10% and 40% be determined in the anti-gravity position by measuring subjectively the patient's assistance in the test movement. The patient relaxes the part so that the examiner can feel the weight of the part. As the patient then attempts the test movement against gravity, the examiner subjectively measures the amount of weight the patient takes (that is, the decrease in weight of the part). One might describe the grading by saying that a 20% muscle requires moderate assistance by the examiner; a 30% muscle requires slight assistance by the examiner. The examiner should guide the movement and give assistance but must not precede the patient in the effort to move the part. If the examiner's assistance is applied too quickly he will not be able to gauge the patient's muscle strength.

Modification of the generally accepted 20% and 30% grading procedures is considered justifiable. It is no more subjective to estimate the amount of assistance given to a weak muscle in order to obtain a grade of 20 to 30% than to estimate the amount of pressure that is applied in grading from 60 to 100%. From the standpoint of treatment it is more important to grade accurately above than below 50%. If a test in the anti-gravity position determines that a muscle has a strong trace of power but is less than fair, the most that can be gained by changing the position of the patient is the distinction between a trace and poor grade, unless a more selective scale of grading is desired (as described below). Patients should not be subjected to unnecessary procedures in examination if the result obtained is relatively unimportant.

The completion of arc of motion in a sidelying position for such muscles as hip extensors, hip flexors, quadriceps and hamstrings is a convenient measure of an objective grade of poor but there are variable factors which make such grading inaccurate. The surface of the table may be smooth or rough, changing the amount of friction and resistance considerably. The strength of hip abductors (if the upper leg is being tested, or of hip adductors if the under leg is being tested) may make a very material difference in results of the flexor and extensor tests. If such muscles are strong they will tend to share some of the weight as the flexors or extensors perform the movement, and if such muscles are paralyzed, the full weight of the extremity will rest on the table and make flexion and extension movements more difficult.

The gravity-eliminated position is used to advantage in grading strength of hip adductors and abductors and elbow flexors and extensors. When used in testing Class II muscles the manner of grading is based on the range of motion and follows the pattern as outlined for Class I muscles. The letters "GE" (gravity-eliminated) follow the grade to denote the modifications.

A small arc of motion	20% GE
A moderate arc of motion	30% GE
Almost complete arc of motion	40% GE
Complete arc of motion	50% GE
Complete arc of motion plus minimum pressure	60% GE
Complete arc of motion plus medium pressure	70% GE
Complete arc of motion plus maximum pressure	80% GE

The grade of 80% GE compares closely with the grade of 50% (anti-gravity). There is no need for such a grade unless the anti-gravity

position is one of strain or discomfort to a patient. On the muscle chart, grades of 50% and above are recorded in blue ink and grades below 50% in red ink. Since 50% CF, 60% GF and 70% GF grades represent less strength than 50% anti-gravity, these CI grades should be recorded in red. The value of these grades has been denoted on the key to grading by the use of red ink.

A 40% grade in Class I muscles indicates the ability to almost complete the arc of motion and is a relatively objective grade.

In Class II muscles the 40% is also relatively objective. Before discussing this section in detail it is necessary to explain the use of *test position* in relation to grading.

Introduced into the grading is the principle that the muscle strength required to hold the test position (see p. 6) may be considered the equivalent of the muscle strength which is required to complete the arc of motion. In some muscle tests the bone on which the muscle is inserted moves from a position of suspension in the vertical plane (gravity-eliminated) toward the horizontal plane (anti-gravity). Quadriceps, deltoid, and hip rotators tested in the sitting position, and triceps and shoulder rotators tested in the prone position compose this group. The muscle strength required to hold the test position against gravity will usually perform the arc of motion against gravity.

In a few tests the bone on which the muscle is inserted moves from a horizontal position toward a vertical position and the test position will be held with slightly less strength than is required to perform the arc of motion. The tests in which this occurs are of the hamstrings tested by knee flexion in the prone position, and of the elbow flexors, triceps, and pectoralis major tested in the supine position.

In the remaining muscle tests the bone on which the muscle is inserted maintains a relatively horizontal position, and one finds few exceptions to the general rule that the arc of motion can be performed if the test position can be held.

When the part is placed in the anti-gravity test position, a muscle which is less than 50% will not be able to hold. Sometimes the drop is sudden and at other times the weight of the part is almost sustained by the strength of the muscles being tested. The gradual release from test position is denoted by the grade of 40%.

For certain muscles the ability to move the part through the anti-gravity arc of motion almost to completion may be indicated by the grade of 40%. These muscles (quadriceps, hip rotators and deltoid tested in the sitting position, and triceps and arm rotators tested in the prone position) move the part from a gravity-eliminated position toward the horizontal anti-gravity position. The leverage exerted by the weight of the part increases as the part moves toward completion of arc. Thus, almost completing the range of motion becomes equivalent to almost holding the weight of the part against gravity.

The phrase "completion of the anti-gravity arc (or range) of motion" appears in the Key to Grading and is used instead of the customary phrase "complete range of motion against gravity."

"Complete range of motion against gravity" is an ambiguous phrase. Frequently the complete range of motion in a test is not against gravity. In the hamstring test in the prone position, the movement from horizontal up to vertical may be considered against gravity. But completion of the range of motion for the hamstrings would consist of flexion beyond the range of motion against gravity. The completion of movement would no longer be hamstring action but would involve gravity flexion with or without a gradual relaxation of the quadriceps. In the test of quadriceps in the sitting position complete range of motion would entail a movement starting from a position of full knee flexion. Actually the part of the range of motion which is used in a test movement is the anti-gravity part of the full arc of motion.

A 50% muscle holds the test position or performs the arc of motion (against gravity for Class II muscles). Grades from 60% to 100% are based on the ability of the muscle to hold the test position (anti-gravity for Class II) against pressure, or to perform the arc of motion

(anti-gravity for Class II muscles) and hold against pressure by the examiner

There is necessarily a subjective evaluation based on the amount of pressure applied but the amount of pressure is in a sense often visible to an observer Differences in strength are so apparent that frequently an observer who understands grading can estimate the strength with a high degree of accuracy

Pressure must be applied *very gradually* in order to determine the degree of strength in muscles above 50% The patient must be allowed to "set" his muscles against the examiner's pressure The amount of pressure necessary to cause the muscle to yield is the measure for grading up to 100% Unless pressure is applied gradually the examiner cannot gauge the degree of muscle strength because slight pressure applied suddenly can 'break' the pull of a muscle of any strength ranging from 60% to 100%

The ability of a muscle to hold against a slight or minimum amount of pressure will indicate a grade of 60% to 70% a medium amount a grade of 80% to 90% and a maximum amount a grade of 100% In grading 100% it may be injurious to the muscle if the examiner attempts to force it to yield The 100% or standard usually is based on the judgement of the examiner Pressure applied by the examiner varies according to the part and according to the size of the patient

In many instances an estimate of 100% may be considered as the ability of the muscle to hold the part against sufficient pressure to displace the body weight proximal to the tested part In the sitting position a normal quadriceps will hold the knee extended against so much pressure that the buttocks will be raised up from the table

The 100% is not intended to indicate the maximum strength but rather what might be termed a 'full strength of the muscle To become competent in judging this full strength an examiner should acquaint himself with the strength of normal non paralytic individuals of various age groups

The use of the percentage scale of grading from 0 to 100% is recommended In general such percentage grading can be directly translated into the symbols used *in other systems of* muscle evaluation but the use of figures has some definite advantages over the use of words in expressing such grades In research work in which studies are made of the amount of change in muscle strength numerical grades can be used directly in computations Percentages are a widely understood numerical evaluation and need little interpretation Such words as good and 'normal' are free for use in interpretation of grades if not used in the scale of grading

The Use of the Word Normal in Relation to Muscle Testing

The word normal needs to be defined in relation to muscle testing and its use limited to avoid the confusion that now arises from its dual meaning

In many systems of grading 'normal is the highest grade in the scale and indicates sufficient strength to take the weight of the part against gravity plus maximum 'resistance' If the grade of 'normal as so defined always represented a normal or expected accomplishment, then the word could be used interchangeably in grading and in interpretation But such is not the case and a choice must be made between the two uses of the word The word is needed in interpretation and should therefore be avoided in the scale of grading

The word normal is needed to describe the muscle strength that is either *natural* or *acquired* at various age periods For most muscles normal is represented by 100% strength But certain muscles at various ages possess a normal strength which is less than the 100%

Two muscle groups show *natural* weakness namely the anterior neck and abdominal muscles An infant is not expected to be able to lift the weight of the head or flex the trunk from a supine position. The inability to perform these movements is accepted as normal for these muscles Under ordinary circumstances the muscle strength increases up to a maximum as the child grows older Muscle strength should be graded so far as possible in relation to the 100% standard and the grade should be recorded

as well as the interpretation of the grade 50% anterior neck muscle strength which indicates the ability to support the weight of the head in an anti-gravity position may be considered the normal accomplishment at the age of 5 30% strength is normal for a 3 year old child. Such grades should carry the notation on the chart "normal for age" Non paralytic adults frequently have no more than 60% strength in the anterior neck muscles Such weakness should not be interpreted as indicating any neuromuscular condition However 60% strength should not be accepted as a desirable normal

The following table lists the muscle strength which may be considered "normal for age" in the anterior neck muscles (Individual variations account for the age-overlap)

Infant to age 4	20% to 40%
4 to 6	50%
6 to 8	60%
8 to adult	80% to 100%

(For table regarding abdominal strength which may be considered normal for age see p 18)

The *acquired* weaknesses to which this discussion specifically refers are those which develop as a result of postural and occupational strain Weakness which develops as a result of strain usually does not drop below the 50% grade But 50% and 60% strength might be interpreted as neurogenic if one were not aware that such degrees of weakness might exist as a result of postural strain

The following muscles tend to show evidence of acquired postural weakness

Toe flexors (brevis and lumbricales)
Middle and lower trapezius
Upper back erector spinae
"Lower" anterior abdominals
Anterior neck
Right hip abductors, Right hip external rotators, Left tibialis posticus } in right handed individuals
Left hip abductors, Left hip external rotators, Right tibialis posticus } in left handed individuals (but less consistently than the pattern in right handed as explained below see fig 6)

The anterior neck muscles and the "lower" anterior abdominals appear as muscles which exhibit both natural and acquired weakness This is a significant factor in understanding the prevalence and persistence of abdominal and anterior neck weakness among many adults If postural strain is superimposed on the natural weakness before normal increase in strength has occurred the muscle will tend to remain weak

An analysis of the postural fault associated with the acquired weakness makes obvious the relationship (Illustrated and described in figures 5 and 6)

In the anterior neck and abdominal muscles average strength in (non paralytic) children tends to establish the grade which may be accepted as "normal" In muscles exhibiting acquired weakness average strength often does not represent an acceptable "normal" Normal strength should be regarded as the degree of strength which is natural for or expected of a muscle or muscle group without disability deformity or pain To establish the acceptable normal paralytic cases are omitted and non paralytic cases are classified on the basis of (1) faulty posture and (2) so-called normal The so-called normal should represent those without disability postural defects or pain and the average in this group may then constitute the "normal" to be used as a standard

Among faulty posture cases the average strength of most of the muscles which show acquired weakness ranges from 60% to 70% Among adults with painful conditions due to faulty mechanics the degree of strength in these muscles also averages between 60% and 70% Muscle strength in these particular muscles among adults with good postural alignment usually grades 80 to 100% In all of the muscles listed as showing acquired weakness the range of strength from 80% to 100% may be regarded as normal

As stated previously acquired weakness does not usually drop below the 50% grade It is not uncommon however to find a greater degree of stretch or strain weakness in certain muscles Toe flexor strength among so-called normal adults (particularly adult women) may vary

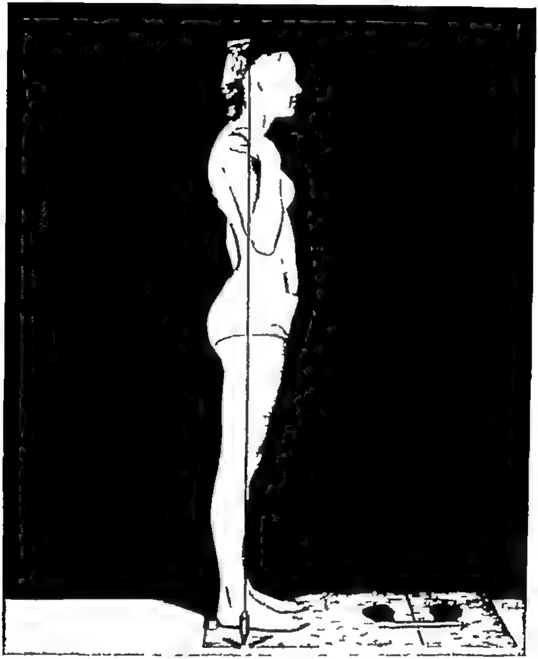


Fig 5 Muscle weakness as related to faulty posture (lateral view)

Forward Head

The cervical spine is in hyperextension, and the anterior vertebral neck flexors are in a position of stretch and strain.

Kyphosis with Forward Shoulders

The upper back erector spinae and the middle and lower trapezius are in position of stretch and strain.

Anterior Pelvic Tilt (Lordosis)

The "lower" anterior abdominal muscles are in position of stretch and strain.

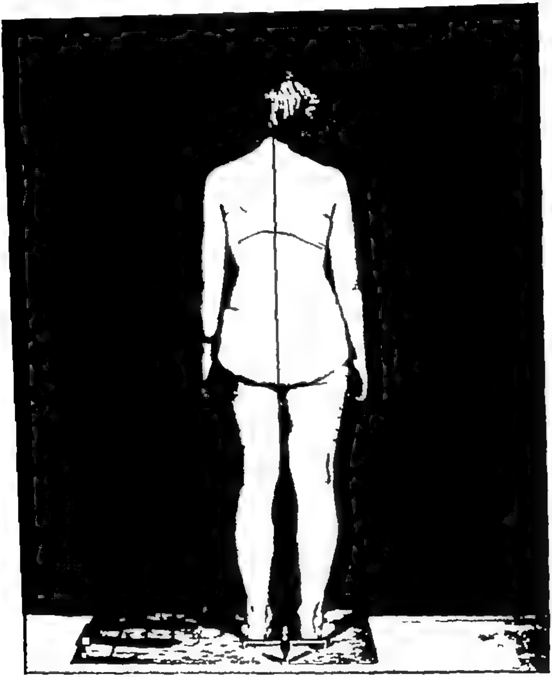


FIG 6 Muscle weakness as related to faulty posture (posterior view)

UNILATERAL PELVIC TILT (High on Right)

The right hip abductors are in position of stretch and strain

PRONATION OF LEFT FOOT (More than Right)

Strain on posterior tibial muscles, left more than right

Right handed individuals tend to assume the standing position as illustrated by this figure (The dropping of the right shoulder is compensatory for the right high hip) In left handed individuals, there is a tendency toward the opposite picture These findings in left handed individuals are less constant than those in right handed individuals, probably because many functions (recreational or occupational) require right handed activity by left handed individuals.

from 40% to 100% The strength of the average child's toe flexors is greater than that of adults and the 100% strength as demonstrated by a child is used as standard One becomes so accustomed to toe flexor weakness among adults that he may rightfully assume that a degree of weakness is 'normal' in the sense that normal is average But the value of comparison in muscle testing is lost if one permits himself to record 'normal' on the chart when the strength is actually only 60% Marked weakness of toe flexors is almost invariably associated with a disability and the word normal should not apply to such weakness unless one is ready to accept disabilities as normal.

The following chart shows 'normal for age' in strength of anterior abdominal muscles (on the basis of tests outlined in Chapter V)

TRUNK RAISING TEST FOR UPPER ABDOMINALS

Infants The trunk raising test is not used because of the extent of anterior neck and abdominal weakness.
Age 4–5 40% to 60%.
6–8 60% to 80%.
9–12 80% to 100%.
12 to adults 100%.
Adult (both sexes) 100%.

LEG-RAISING FOR LOWER ABDOMINALS

Infants The leg-raising test is not used because the weight and leverage exerted by the legs is not in proportion to that in older children.
4–12 60% to 70%.
12 to adults 70% to 80%.
Adult (women) 80%.
Adult (men) 100%.

An examiner must build a basis for comparison of test results through experience in muscle testing Such experience is necessary on both paralytic and non-paralytic individuals

The experience of many individuals engaged in muscle testing has been limited to examination of paralytic patients The result is that their idea of normal strength tends to be a measure of what appears to be good functional recovery following weakness rather than an estimate of the non paralytic normal.

The authors recommend that an examiner make an effort to test a series of non paralytic individuals of various ages Such a series should include both male and female and those with faulty as well as those with good posture

If it is not possible to examine a series of non paralytic cases every effort should be made to examine the trunk and unaffected extremities in cases involving only one or two extremities.

Testing and grading procedures are all modified in the examination of infants and young children to the age of 4 or even 5 The ability to grade a child's muscle strength up to 50% is usually not difficult but the grading above that depends on the cooperation of the child in holding against pressure Young children seldom cooperate to any extent in strong test movements Very often tests must be recorded as apparently normal or 50+ which indicates that it may be normal though one hesitates to label it as such

SUGGESTED ORDER OF MUSCLE TESTS

1 Supine
Toe Flexors
Toe Extensors
Tibialis Anticus
Tibialis Posticus
Peroneals
Tensor Fascia Femoris
Sartorius
Ilio-Psoas
Abdominals
Neck Flexors
Finger Flexors
Finger Extensors
Thumb Muscles
Wrist Extensors
Wrist Flexors
Supinators
Pronators
Biceps
Brachio-Radialis
Triceps (Alternate)
Pectoralis Major Clavicular Part
Pectoralis Major Sternal Part
Pectoralis Minor
Internal Rotators of Shoulder (Alternate)
Teres Minor and Infraspinatus
Serratus Anterior
Anterior Deltoid (Alternate)

2. Side Lying
   - Gluteus Medius
   - Gluteus Minimus
   - Adductors
   - Lateral Abdominals

3. Prone
   - Gastrocnemius and Plantaris
   - Soleus
   - Hamstrings (Inner and Outer)
   - Gluteus Maximus
   - Neck Extensors
   - Erector Spinae
   - Quadratus Lumborum
   - Latissimus Dorsi
   - Lower Trapezius
   - Middle Trapezius
   - Rhomboids
   - Triceps
   - Teres Major
   - Internal Rotators of Shoulder
   - External Rotators of Shoulder

4. Sitting
   - Quadriceps
   - Internal Rotators of Hip
   - External Rotators of Hip
   - Hip Flexors (Group)
   - Deltoid (Three Parts)
   - Coracoid-brachialis
   - Upper Trapezius
   - Serratus Anterior (Alternate)

5. Standing
   - Serratus Anterior
   - Ankle Plantar Flexors

CHAPTER II

NERVE AND MUSCLE CHARTS USED IN RECORDING MUSCLE EXAMINATIONS

The charting of test results is an important part of muscle examinations. It is done for the specific value of such records in diagnosis, prognosis and treatment—not merely for the purpose of maintaining a record. The charts should permit complete tabulation of test results, and their arrangement should facilitate interpretation.

Four types of charts are illustrated in this chapter and each type has its specific use and value. They may be classified briefly as follows:

- Diagnostic Charts for Nerve Lesions
- Cranial Nerve Chart
- Poliomyelitis Charts
- Body Mechanics Chart

Diagnostic Charts for Nerve Lesions

The Diagnostic Charts for Nerve Lesions (charts 1 through 4) have been designed especially for use in lesions of the spinal nerves. The distribution of motor involvement as determined by muscle tests indicates whether there is a lesion of a nerve root, cord, or peripheral nerve. The chart is useful also in determining the level of lesion in transverse myelitis cases.

The charts (in tablet form) are arranged so that the muscle nerve section and sensory drawings appear on the front (see charts 1 and 3), and the corresponding Spinal Motor Nerve and Anatomical Motor Point drawings appear on the back of the sheet (see charts 2 and 4).

The front of the chart furnishes a record sheet and a complete table of the peripheral and spinal segment nerve supply for each muscle. The back of the chart shows the course of the spinal motor nerves from their origin to their motor point insertions into the muscles.

The mechanics of the charts is described by discussing each section in detail.

MUSCLES

On the upper extremity chart are listed all muscles which are supplied by the cervical nerves (and the first thoracic as it enters into the brachial plexus). The trunk and lower extremity chart lists intercostal, back, abdominal and lower extremity muscles supplied by thoracic, lumbar and sacral nerves. The muscles are listed in order of nerve innervation. Though all the muscles named cannot be evaluated in muscle testing, the list has been made complete for the purpose of reference.

The heavy lines separate the muscles into groups innervated by each peripheral nerve or group of nerves listed at the top and at the left of the chart.

PERIPHERAL NERVES

Peripheral nerves (left to right across the top of the page) are listed in their order of branching. Because most of the peripheral nerves arise from the trunks or cords of the plexus, the proximal-distal distribution of branching has taken precedence over the superior-inferior distribution in determining the order of listing. In general, however, the level of branching from the spinal cord has been observed also in listing cervical, then thoracic on the upper extremity chart, and thoracic, lumbar, and sacral in that order, on the lower extremity chart.

The lateral, medial, and posterior cords from which the peripheral nerves are derived are designated along the side and the top of the upper extremity chart by the initials L, M, and P. In the lower extremity charts the dorsal and ventral divisions of the trunks are denoted by the initials D and V. The regions from which the spinal nerves originate are shown at the tops of the charts as follows: C refers to cervical, T to thoracic, L to lumbar, and S to sacral. The

x in the small square opposite each muscle name denotes the peripheral nerve supply for each muscle

SPINAL SEGMENT

The spinal segment innervation of nerves is designated beside the names of the peripheral nerves at the top of the chart. The spinal segment innervation of muscles is denoted by the X's which appear under the section headed Spinal Segment.

Anatomy and neurology text books vary in regard to the data on spinal segment innervation. (In some cases, information as it appears in one section of a book does not agree exactly with that in another section of the same book.) The differences indicate either wide individual variations as seen in anatomical studies or a lack of exact information.

To obtain a concensus of opinion, a compilation was made by charting the information from six different sources, namely Gray, Morris, Quain, Spalteholz, Foerster, Haymaker and Woodhall. (The spinal segment table in Haymaker and Woodhall is modified after Bing.) These six were selected because they represent well known authorities in the fields of anatomy and neurology and because the material needed for this study was readily available in their texts.

The information obtained from each source is included for the benefit of those who are interested in comparing the data. (Tables I and II.)

In Foerster and Haymaker and Woodhall the charts appear in graphic form with solid lines extending completely or partially through a space which designates a spinal segment. In reinterpreting this type of information the authors have used the large X to denote entire segment, the small x to denote 1/2 (or in Foerster 1/4 to 3/4) and an (x) to denote less than 1/4 the space which in the text referred to full spinal segment innervation. In the remaining references, the small x denotes the spinal segment supply, the large X denotes major supply (as indicated by bold type in the reference used) and a parenthetical (x) denotes possible or infrequent supply.

In the authors' compilation as it appears at the extreme right of the table, the x's have been used in a different manner representing an arithmetical summary. If five or six authorities agreed that a spinal segment supplied a given muscle, the nerve supply was indicated by a large X; if three or four agreed, the nerve supply was indicated by a small x; if only two agreed, the nerve supply was indicated by a small parenthetical (x). Spinal segment nerve supply given by only one of the six was disregarded. For example:

Triceps

Gray			7	8	
Morris		6	7	8	
Quain	5	6	7	8	
Spalteholz		6	7	8	(1)
Foerster		(6)	7	8	1
Haymaker & Woodhall			7	8	1
	1	4	6	6	3
		x	X	X	x

In the case of a few muscles no information was given about spinal segment supply by two of the sources. When this occurred, agreement by three or four sources was indicated by a large X, two by a small x and one by an (x).

The compilation tends to retain the significance of the large X in denoting chief supply (as done individually by the authorities). In only two instances was this emphasis lost by the manner of charting. There was general agreement that C3, 4, 5 was the supply to the diaphragm with C4 as chief supply, and that C5, 6 was the supply to the brachio-radialis with C6 as chief supply. The arithmetical compilation required the use of the large X for all the segments in both of these muscles with the result that emphasis on chief supply was lost.

In a few instances it proved advisable or necessary to modify the compilation. After the compilation was completed it was found that the spinal segment to the peripheral nerves and to the muscles they supply were not always in agreement. The spinal segment supply to the muscles might be less than to the nerve, but should not exceed the supply to the nerve. Modifications were made by deleting the paren-

thetical (x) in the few instances shown by the delete sign (ω) on the tables This was done in *order that the spinal segment supply to the peripheral nerve* (as seen at the top beside the name of the nerve) and the spinal segment supply to the muscle be in agreement

In one instance it was necessary to indicate additional peripheral nerve supply to a muscle to cover the spinal segment supply The lateral anterior thoracic was added as peripheral nerve supply for the pectoralis minor to cover C6 and 7 segmental supply

C7 was added to C8 T1 as ulnar nerve supply because many of the muscles under ulnar nerve were listed as having possible C7 supply (Not infrequently the ulnar nerve receives a C7 twig according to Quain)

The authors have modified the compilation in regard to spinal segment supply to the clavicular and sternal portions of the pectoralis major No division was made in the listing of this muscle in the references used Both Quain and Gray however have indicated that the lateral anterior thoracic nerve gives off a branch to join the medial anterior thoracic which goes on to supply the minor and lower part (sternal) of the major They do not indicate that a branch from the medial joins the lateral in supplying the upper (or clavicular) portion of the major On the basis of this information the authors have divided the segmental supply to the pectoralis major as shown on the diagnostic chart

SENSORY

Sensory findings can be recorded on the diagrams of the extremities which are provided at the right side of the chart The drawings may be used as anterior or posterior right or left by simple adaptations The outline of fingernails may be added to the arm drawing and a heel contour to the antero-posterior leg drawing to make them appear as posterior views

It would have been desirable to have a reference section on the charts showing the dermatome and cutaneous peripheral areas but space did not permit this addition Such charts appear in this text for reference purposes (see charts 7 and 8) (These have been reproduced from *Neuroanatomy* by Strong and Elwyn.)

SPINAL MOTOR NERVE AND ANATOMICAL MOTOR POINT CHARTS

Drawings which indicate the course of the motor nerves from the spinal cord to the muscle insertions appear on the back of the diagnostic charts These illustrations facilitate interpretation of the motor findings as recorded on the front of the chart and aid in determining the site or level of a lesion They have been drawn by an anatomical artist from information that the authors have extracted from numerous text books of anatomy (see Preface) Every effort has been made to preserve anatomical accuracy in the outline of the course of the nerves. Cross section illustrations available in some texts were used to check the positions of the nerves at various levels

Yellow has been used to indicate all nerves except posterior divisions and their branches The latter are shown in orange To stress the significance of motor points these have been depicted diagrammatically by red dots

The information regarding anatomical motor points was obtained from careful study of drawings and textual material in the reference books used When the project of making this chart was first undertaken, electrical motor point charts were investigated with the thought that they might act as a guide in locating the anatomical motor points Such charts were found to be of no use for this purpose and subsequently were discarded Unquestionably points of electrical stimulation are determined on the basis of best individual muscle response rather than on the basis of anatomical motor point Overlap of muscle belly and closeness of anatomical motor points make it necessary to move the electrode laterally proximally or distally to obtain the desired muscle response In referring to motor points a distinction should be made between electrical and anatomical motor points

USE OF THE CHARTS IN DIAGNOSIS

Muscle strength grades are recorded in the column to the left of the muscle names. The

rades may be in percentages (as recommended n this text) or in other numeral or letter symbols

After muscle strength has been recorded the nerve supply of the weak muscles is indicated by a circle around the corresponding x (See charts 7 through 10) The indication of nerve involvement is readily interpreted by following the verticle line upward to the names of the nerves involved Heavy black lines are then drawn in to designate the area or level of the lesion The reverse side of the chart is used to aid in further visualizing the level of motor nerve involvement

Only one examination of one extremity can be recorded on a chart but repeated examinations can be viewed by placing succeeding charts in such a position that one overlaps the other except for the grading column on the left

The use of the diagnostic charts may best be illustrated by analyses of case records

CASE 1 (chart 9) This male age 28 had poliomyelitis (onset 8–13–47) with left arm involvement Five weeks later he developed a secondary nerve involvement of the right arm. The record of the poliomyelitis weakness is mentioned only because of its relation to the peripheral nerve involvement of the opposite extremity

8–27–47 Admitted Children's Hospital School as an outpatient The only residual weakness at this time was of the left deltoid which graded 10% anterior and middle and 20% posterior A temporary arm splint was applied held to the body with straps around the abdomen and over the right shoulder

9–5–47 The patient was reexamined The deltoid graded 30% Improvement seemed rapid so the temporary arm splint was retained instead of being replaced by a permanent type brace

9–10–47 On reexamination the deltoid graded 40% However the patient showed secondary involvement of the right hand with sensory and motor changes The presence of considerable ulnar and partial median involvement as denoted by the muscle-nerve check suggested a lesion of the medial cord of the plexus It was considered possible that the strap across the right shoulder was causing pressure so the strap was padded to relieve any such possible pressure in this area

10–10–47 The right arm was normal except for very slight sensory disturbance in the area which previously showed complete anaesthesia The left deltoid graded 70% The splint was removed for half-days and the patient was instructed to increase the time without the splint as the arm gained in strength

1–5–48 The right hand was normal and the left deltoid graded 100% (Use of the splint had been discontinued about six weeks previously)

CASE 2 (chart 10) This chart shows the results of a muscle test on a child who had residual muscle weakness from a brachial plexus lesion caused by an automobile accident six years previous to the time of this examination. An analysis of the chart discloses the following The posterior cord is apparently torn at about the level of the axillary nerve since the deltoid is graded only 30% Below the level of the axillary branching this cord becomes the radial nerve and the muscles supplied by it are not active The medial cord on the basis of the ulnar nerve supply is not intact The lateral cord apparently is intact because the biceps through the musculo-cutaneous is normal and some of the muscles supplied by the median nerve (which has dual supply from the lateral and medial cords) are active

CASE 3 (chart 11) This 61 year old male injured his left arm when he fell on the ice The day after the injury he was seen by a physician and the case was diagnosed as a dislocated shoulder and a wrist drop The dislocation was reduced and a plaster splint applied to the fore arm and hand. After three weeks the patient stated that his shoulder and upper arm disability had disappeared but he was unable to use the hand and fingers and there was numbness of the entire hand There was no history of previous dislocations Five weeks after injury a muscle nerve check was done The findings presented the following possibilities

1 A single lesion in the mid humeral region below the level of the medial triceps branch with

(a) complete involvement of the radial
(b) almost complete involvement of the ulnar and
(c) partial involvement of the median

A mid humeral lesion was not probable in this case because a blow on the arm posteriorly would not cause pressure anteriorly

2 A dual lesion

(a) mid humeral with complete involvement of the radial below the level of the medial triceps branch
(b) medial cord of the plexus with almost complete involvement of the ulnar and partial of the median

There was an interval of 5 weeks between the injury and the first muscle examination If one considers the possibility of complete involvement at plexus level originally it would carry the assumption that the musculo-cutaneous and radial had regenerated to the mid humeral level in five weeks This does not appear likely

The dual lesion is the most probable although it is a highly selective type of injury

Case 4 (chart 12) This chart demonstrates the muscle test results on a post-operative case in which the question arose whether the paralysis resulted from operative interference or tourniquet pressure This 27 year old male had suffered a compound fracture of the left humerus as a result of an automobile accident in August 1947 The fracture was treated by the use of two long screws and stainless steel wire Following this the wound healed but the elbow remained nearly stiff at 90 degrees In January 1948 he fell on the street and reinjured the elbow Three weeks later he was seen in the Johns Hopkins Hospital where X rays revealed an old intercondylar fracture of the left lower humerus in displaced position not being adequately held by the screws and wire There was a new undisplaced fracture in the supra condylar section of the old fracture Callus old and new was abundant There was no evidence of muscle weakness

In February 1948 under a tourniquet a hemi arthroplasty of the left elbow was performed through a posterior approach The ulnar nerve was dissected free and carefully retracted The cartilage of the radius and ulna were intact but the lower humerus was completely distorted and covered with callus The callus screw and wires and part of the lower humerus were removed A new condyle was carved out. The radial and median nerves were anterior and were not seen. On completion of the procedure the elbow was freely movable through a full range of motion. No fascia was removed The tourniquet had been in place for two hours and twenty minutes.

After the operation the patient had no power to move the hand or lower arm He had paresthesia of the entire arm with anaesthesia over the ulnar nerve distribution The patient was first in a plaster splint then in a sling with a Bunnell splint for the hand The wound healed well and passive motion was continued until discharge About three months after operation some flexion of the fingers became possible

On April 20 1948 a muscle-nerve check was done This examination indicated that the paralysis was the result of tourniquet pressure rather than operative interference The musculo-cutaneous nerve was involved below the level of the branches to the coraco-brachialis The radial nerve was involved below the level of the branch to the long head of the triceps, indicating a lesion slightly below the level of the axilla Operative interference at elbow level would not have affected the nerve supply to the biceps brachialis or lateral and medial heads of the triceps

Case 5 (chart 13) This chart shows the diagnostic value of muscle testing in a club-foot case

The child age 6 had been treated as a congenital club-foot at an early age Corrective casts had been applied and a tendo-Achilles lengthening had been done at the age of two years Massage and stretching both preceded and followed the operation The child continued to walk with a limp and the deformity persisted

1-15-48 Admitted Children's Hospital School No shortening of either leg Atrophy of the left calf and foot Small depression quite hairy to the right of third lumbar vertebra suggestive of a spina bifida

1-17-48 X rays (antero-posterior and lateral) revealed some malformation in the lumbar region

1-20-48 Muscle-nerve check shows nerve involvement L4 and below

Cranial Nerve Chart

The cranial nerve chart is designed for use primarily as a reference sheet and secondarily as a record sheet for functional examinations of the muscles of expression (Illustrations and textual material relative to facial muscle tests may be found in Chapter VI) This chart was not intended for diagnostic purposes although it may have some value as such

The cranial nerve chart consists of two sections On the front (see chart 5) are listed all the cranial nerves and the general regions and specific muscles or organs which they supply A column is provided at the left of the muscle names in which to record evaluation of strength of those muscles which can be tested At the right of the page are outlines of the head on which sensory findings can be recorded

Because of the dual purpose of the chart as a reference and a tabulation sheet it contains some material that would not be included in a chart used only for recording muscle examinations For example all the cranial nerves are listed whether they are sensory motor or mixed nerves Some muscles are included which can not be tested either individually or in groups (In a few cases muscles have been listed in groups instead of individually because of the need to conserve space)

The back of the chart (see chart 6) contains two drawings of the head The one on the right shows the superficial musculature The one on the left is a sagittal section of the skull at about the center of the left orbit (except that the complete eyeball is shown) The muscles depicted are mainly those of the tongue the pharyngeal area and the eyeball

The left hemisphere has been reflected upward to show the inferior surface of the brain and the cranial nerve roots Connecting the nerve roots with the corresponding nerve trunks in the lower section of the drawing are lines bearing the numbers of the respective cranial nerves Sensory nerve roots and cut ends are left white The motor and mixed nerves are shown in yellow (except that only the small motor branch of the fifth is colored)

On the drawings and in the legend the cranial nerves are denoted by Roman numerals the nerve branches by small letters and the muscles by Arabic numerals The muscles listed in the legend include a few which could not be shown in the drawings or in the table on the front of the chart

Poliomyelitis Charts

The four poliomyelitis muscle charts are classified as follows Upper extremity lower extremity abdominal and respiratory (See charts 14 through 17)

These charts are used chiefly for diagnosed cases of anterior poliomyelitis or other forms of myelitis in which a series of periodic examinations is anticipated

Usually recording of grades on this type of chart is not done for diagnostic purposes although such records sometimes aid in establishing a diagnosis Non traumatic myelitis cases and poliomyelitis cases often present similar findings In such cases muscle testing may be useful in differential diagnosis As recorded on the poliomyelitis charts no recognizable pattern of weakness can be found in extensive poliomyelitis involvement (See charts 18 19 and 20) The weakness in a non traumatic myelitis case frequently resembles a poliomyelitis case in its lack of pattern *unilaterally* but *bilaterally* there may exist a striking symmetry (See chart 21) When muscle strength improves this type of myelitis case usually continues to show the same pattern of symmetry in succeeding examinations (See chart 22)

Charts in which the results of repeated examinations can be seen in close relationship may aid in diagnosis of conditions characterized by

progressive muscular weakness The progression and distribution of such weakness may be indicative of the type or site of lesion present Loss of muscle strength associated with specific types of lesions should not be confused however with loss of strength due to excessive or faulty treatment A careful analysis should be made of all contributing factors

Body Mechanics Examination Chart

The Body Mechanics Chart (chart 23) is used for the purpose of recording examination findings in cases of faulty posture scoliosis and postural low back or upper back pain. Postural defects muscle weakness or tightness and plumb-line measurements may be recorded in the examination sections of the chart The treatment section of the chart is arranged to permit the outlining of the physical therapy indicated The manner of recording examination findings and the treatment outline as based on such findings are illustrated by the case record presented (See chart 24)

The term Body Mechanics Chart is used rather than Posture Chart because it is more inclusive Although poor body mechanics will usually appear as a noticeable postural fault such may not be the case Muscle weakness is a defect so far as body mechanics is concerned but not infrequently the posture may be good

Just as muscle test results are useful in paralytic cases for the purpose of determining the kind and amount of exercise therapy that is indicated they are also useful in non paralytic cases of faulty body mechanics On the basis of test results treatment is outlined for the purpose of correcting faulty alignment strengthening the weak muscles and stretching the short or contracted muscles

Unless exercises are selected on the basis of muscle tests they cannot logically be regarded as specifically prescribed for the treatment of postural faults or deformities associated with muscle imbalance

Muscle Test Surveys

Single examination records are valuable in diagnosis and in outlining treatment, but from an over all standpoint the greatest value of charts is derived from comprehensive surveys of examination findings which permit large scale comparisons of test results on many individuals

A person doing many muscle tests cannot fail to notice that test results tend to fall into patterns On the basis of many individual cases he begins to evolve generalizations about prognosis and the value of various forms of treatment However this knowledge is subjective and may be colored unwittingly by prejudice

Surveys done from recorded examinations provide generalizations which are objective and need not be colored by prejudice They bring out much valuable information some of which might not before have been recognized They serve either to confirm the impressions gained by examiners or quite frequently to point out errors of fact or emphasis

It is not within the province of this text to discuss survey findings Each examiner should survey his own records for their own particular value When a sufficient number of surveys have been compiled a comparison of these will add still more to the scope of muscle testing as a therapeutic aid

Use of the diagnostic charts should over a period of years furnish very valuable data which can reaffirm or correct the information now given on the charts in regard to spinal segment innervation To be useful such records must be based on careful muscle testing Accurate records of test results on known lesions will furnish valuable information for future study

Some poliomyelitis cases have been surveyed in relation to the spinal segment data on the diagnostic charts There is presented the possibility that poliomyelitis cases may show some interesting spinal segment patterns of involvement For instance there tends to be a rather frequent association of abductor weakness of the hip and dorsi flexor weakness of the foot A study of the spinal segment innervation chart reveals that both these groups are supplied by L4 5 S1 Careful analysis of case records may show a relationship between segmental innervation and segmental muscle imbalance

THE Diagnostic Charts for Nerve Lesions, the Cranial Nerve Chart, and the Poliomyelitis Charts which follow have all been reduced from the original 8½ x 11 inch size, with the exception of charts 2, 4, and 6. These drawings have been reproduced in the actual size as they appear on the back of the diagnostic and cranial nerve charts in tablet form.

TABLE I NECK AND UPPER EXTREMITY

	GRAY									MORRIS									QUAIN								
	SPINAL SEGMENT									SPINAL SEGMENT									SPINAL SEGMENT								
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CERVICAL ERECTOR SPINAE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
INFRA-HYOID MUSCLES	X	X	X							X									X	X	X						
RECTUS CAP ANT & LAT.	X	X								X	(X)								X	X	X	X					
LONGUS CAPITIS	X	X	X							X	X	X	X														
LONGUS COLLI		X	X	X	X	X	X				X	X	X	X	X					X	X	X	X	X	X	X	
LEVATOR ANGULI SCAPULAE			X	X	(X)							X	X								X	X	X				
SCALENI (A. M. P.)		X	X	X	X	X	X						X	X	X	X	X				X	X	X	X	X		
STERNO-CLEIDO MASTOID		X	X								X	(X)								X	(X)						
TRAPEZIUS (U. M. L.)			X	X							(X)	X	X							X	X	X					
DIAPHRAGM			X	X	X							X	X	X							(X)	X	(X)				
SERRATUS ANTERIOR					X	X	X							X	X	X	(X)						X	X	(X)		
RHOMBOIDS, MAJ & MINOR					X									X									X				
SUBCLAVIUS					X	X								X	X								X	(X)			
SUPRA-SPINATUS					X	X								X	X								X	(X)			
INFRA-SPINATUS					X	X								X	X								X	(X)			
SUBSCAPULARIS					X	X								X	X								X	X			
LATISSIMUS DORSI						X	X	X							X	X	X							X	X	X	
TERES MAJOR					X	X								X	X	(X)							(X)	X	(X)		
PECTORALIS MAJ (CLAV.)					X	X	X	X	X					X	X	X	X						(X)	X	X	X	X
PECTORALIS MAJ (STERN.)																											
PECTORALIS MINOR								X	X							X	X	X							X	X	X
TERES MINOR					X									X	X								X	(X)			
DELTOID					X	X							(X)	X	X								X	X			
CORACO-BRACHIALIS							X								X	X									X		
BICEPS					X										X								X	X			
BRACHIALIS					X	X								X	X								X	X			
TRICEPS								X							X	X	X						X	X		X	
ANCONEUS							X	X								X									X	X	
BRACHIALIS (SMALL PART)					X	X								X	X								X	X			
BRACHIO-RADIALIS					X									X	X									X			
EXT CARPI RAD L. & B.						X	X							(X)	X	X							X	X			
SUPINATOR						X								X	X												
EXT DIGITORUM COMMUNIS							X								X	X									X		
EXT MINIMI DIGITI							X									X											
EXT CARPI ULNARIS							X								X	X	X								X		
AB POLLICIS LONGUS															X	X	)										
EXT POLLICIS BREVIS							X								X	X	X								X		
EXT POLLICIS LONGUS							X								X	X	(X)								X		
EXT INDICIS							X										X								X		
PRONATOR TERES						X																		X			
FLEX CARPI RADIALIS						X									X		(X)							X			
PALMARIS LONGUS						X									X										X	X	
FLEX DIGITORUM SUBLIMIS																X	X	X							X	X	
FLEX DIGIT PRO I & II									X																X)	X	
FLEX POLLICIS LONGUS															X										(X)	X	X
PRONATOR QUADRATUS								X							(X)	X	X	X							(X)	X	X
AB POLLICIS BREVIS						X	X								X									X			
OPPONENS POLLICIS															X									X			
FLEX POLL BREV (SUP H.)																X								X			
LUMBRICALES I & II																		X									
FLEX CARPI ULNARIS									X							X		X								X	X
FLEX DIGIT PROF III & IV																X									X	X	X
PALMARIS BREVIS								X									X									X	
ABD MINIMI DIGITI																										X	
OPPONENS MINIMI DIGITI								X																		X	X
FLEX MINIMI DIGITI																										X	
LUMBRICALES III & IV																										X	
DORSAL INTEROSSEI								X																			
PALM INTEROSSEI								X																			
ADDUCTORS POLLICIS																X											
FLEX POLL BREV (DEEP H.)								X																			

SPINAL SEGMENT COMPILATION

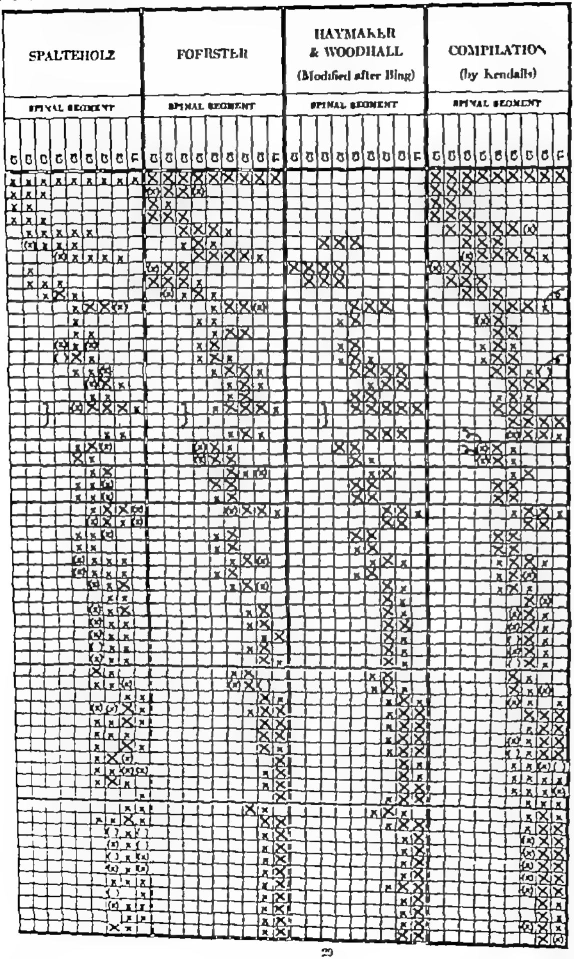
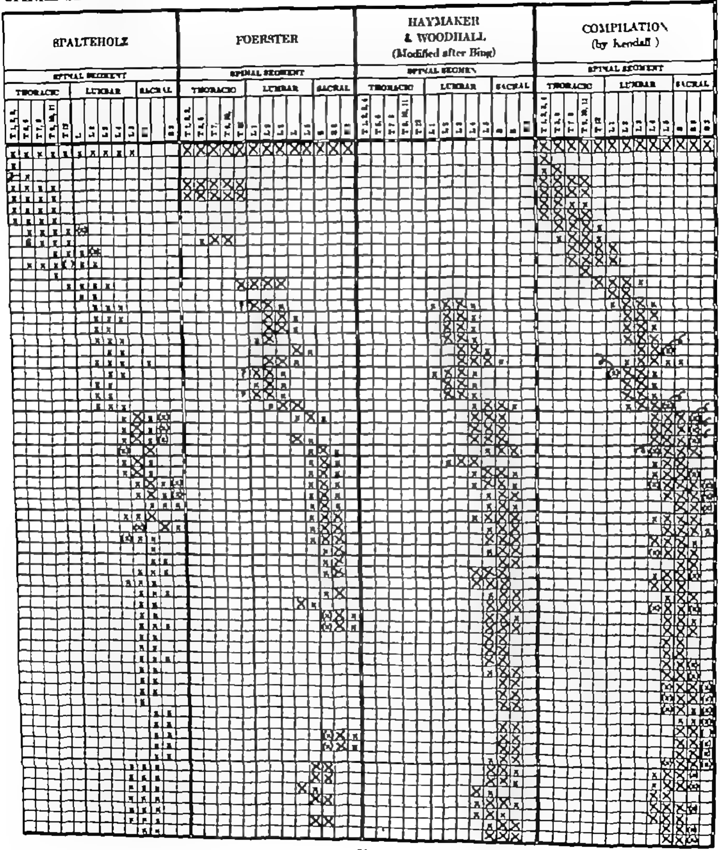


TABLE II TRUNK AND LOWER EXTREMITY

	GRAY													MORRIS													QUAIN												
	SPINAL SEGMENT													SPINAL SEGMENT													SPINAL SEGMENT												
	THORACIC					LUMBAR					SACRAL			THORACIC					LUMBAR					SACRAL			THORACIC					LUMBAR					SACRAL		
	T 1,2,3,4	T 5,6	T 7,8	T 9,10,11	T 12	L 1	L 2	L 3	L 4	L 5	S 1	S 2	S 3	T 1,2,3,4	T 5,6	T 7,8	T 9,10,11	T 12	L 1	L 2	L 3	L 4	L 5	S 1	S 2	S 3	T 1,2,3,4	T 5,6	T 7,8	9,10,11	T 12	L 1	2	L 3	L 4	5	S 1	S 2	S 3
ERECTOR SPINAE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SERRATUS POST. SUP.	X	X												X													X												
TRANS. THORACIS	X	X												X	X												X	X											
INT. INTERCOSTALS	X	X	X	X										X	X	X	X										X	X	X	X									
EXT. INTERCOSTALS	X	X	X	X										X	X	X	X										X	X	X	X									
SUBCOSTALES	X	X												X	X														X	X									
LEV. THE COSTARUM	X	X	X	X										X	X	X	X										X	X	X	X									
EXTERNAL OBLIQUE			X	X											X	X	X											X	X	X	X								
RECTUS ABDOMINIS			X	X												X	X											X	X	X	X								
INTERNAL OBLIQUE			X	X		X										X	X	X	X										X	X	X	X							
TRANSVERSUS ABD.			X	X		X										X	X	X	X										X	X	X	X							
SERRATUS POST. INF.				X													X													X									
QUADRATUS LUMBORUM					X	X	X											X	X	X	X	(X)									(X)	X	(X)						
PSOAS MINOR						X													X	X													(X)						
PSOAS MAJOR							X	X											(X)	X	X	X											X	X	(X)				
ADDUCTOR BREVIS								X	X											X	X	X											X	X	X				
ADDUCTOR LONGUS								X	X											X	X												X	X					
GRACILIS								X	X											X	X	X											X	X	X				
OBTURATOR EXTERNUS								X	X													X												X	X				
ADDUCTOR MAGNUS								X	X												X	X	X											X	X	X	(X)		
ILIACUS							X	X												X	X	X											X	X					
PECTINEUS							X	X	X											X	X												X	X					
SARTORIUS							X	X	X											X	X												X	X					
QUADRICEPS							X	X	X												X	X												X	X	(X)			
GLUTEUS MEDIUS									X	X	X											X	X	X											X	X	X	(X)	
GLUTEUS MINIMUS									X	X	X												X	X											X	X	X	(X)	
TENSOR FASCIA LA.									X	X	X											X	X	X											X	X	X	(X)	
GLUTEUS MAXIMUS											X	X													X										(X)	X	X	X	
QUADRATUS FEMORIS										X	X											X		X											(X)	X			
GEMELLUS INFERIOR										X	X											X	X	X											X	X	X		
GEMELLUS SUPERIOR											X	X	X										X	X	X										(X)	X	X	X	
OBTURATOR INTERNUS											X	X	X										X	X	X										(X)	X	X	X	
PIRIFORMIS											X	X												X	X											(X)	X	X	( )
SEMI-TENDINOSUS									X	X	X	X	X										X	X	X											X	X	X	
BICEPS (LONG HEAD)									X	X	X	X	X											X		X										X	X	X	X
SEMI MEMBRANOSUS									X	X	X	X	X										X	X											(X)	X	X		
BICEPS (SHORT HEAD)									X	X	X	X											X	X	X											X	X	X	
GASTROCNEMIUS											X	X												X	X												X	X	(X)
PLANTARIS									X	X	X											X	X	X											(X)	X	X		
POPLITEUS									X	X	X											X	X	X											(X)	X	X		
SOLEUS											X	X											X	X	X										(X)	X	X	X	(X)
TIBIALIS POSTICUS										X	X												X	X											(X)	X	X	(X)	
FLEX. DIGIT. LONG.										X	X												X	X											(X)	X	X	(X)	
FLEX. HALL. LONG.										X	X	X											X	X	X										(X)	X	X	X	
FLEX. DIGIT. BREVIS																							X													X	X		
ABDUCTOR HALLUCIS																							X	X												X	X		
FLEX. HALL. BREVIS																							X	X												X	X		
LUMBRICALIS ( )																							X	X												X	X		
ABD. DIGITI QUINTI																								X	X												X	X	(X)
QUADRATUS PLANTAE																								X	X												X	X	(X)
FLEX. DIGITI QUINTI																																					X	X	(X)
OPP. DIGITI QUINTI																																					X	X	(X)
ADDUCTOR HALLUCIS																								X	X												X	X	(X)
PLANTAR INTEROSSEI																								X	X												X	X	(X)
DORSAL INTEROSSEI																								X	X												X	X	(X)
LUMBRICALES (II, III, IV)																																					X		(X)
PERONEUS LONGUS									X	X	X											X	X	X											X	X	X	X	
PERONEUS BREVIS									X	X	X											X	X	X											X	X	X	X	
TIBIALIS ANTICUS									X	X	X											X	X	X											X	X	X	X	
EXT. DIGIT. LONG.									X	X	X											X	X	X											X	X	X	X	
PERONEUS TERTIUS									X	X	X											X	X	X											X	X	X	X	
EXT. HALL. LONG.									X	X	X											X	X	X											X	X	X	X	
EXT. DIGIT. BREVIS											X												X														X		

SPINAL SEGMENT COMPILATION

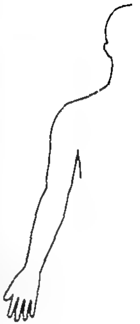


DIAGNOSTIC CHART FOR NERVE LESIONS
UPPER EXTREMITY

Name Date

	Muscle Strength Grade	Muscle	Motor: Cervical C1-4	Accessory Cn 11 C3-4	Phrenic C3,4,5	Long Thorac. C5,6,7	Dorsal Scap. C5	Subclavius C5,6	Supra-Scap. C5,6	Up. Subscap. C5,6	Thoracodorsal C6,7,8	Low. Subscap. C5,6	Lat. Ant. Thor. C5,6,7	Med. Ant. Thor. C8,T1	Axillary C5,6	Musc. Cutan. C5,6	Radial C5-T1	Median C6-T1	Ulnar C8,T1	Spinal Segment: C1	C2	C3	C4	C5	C6	C7	C8	T1
Cervical Nerves		CERVICAL ERECTOR SPINAE																		X	X	X	X	X	X	X	X	X
		INFRA-HYOID MUSCLES																		X	X	X						
		RECTUS CA. ANT. & LAT.																		X	X							
		LONGUS CAPITIS																		X	X	X						
		LONGUS COLLI																			X	X	X	X	X	(x)		
		LEV. TER. ANGULI SCAPULAE																				X	X	X				
		SCALEN (A. M.)																				( )	X	X	X	X		
		STERNO-CLEIDO-MASTOID																		(x)	X	X						
		TRAPEZIUS (M. L.)																			X	X	X					
		DIAPHRAGM																				X	X	X				
Brachial Plexus		SERRATUS ANTERIOR																						X	X	X		
		RHOMBOIDS, MAJ. MINOR																					(x)	X				
		SUBCLAVIUS																						X	X			
		SUPRA-SPINATUS																						X				
		INFRA-SPINATUS																						X	X			
		SUBSCAPULARIS																						X	X			
		LATISSIMUS DORSI																							X	X	X	
		TERES MAJOR																							X			
		PECTORALIS MAJ. (CLA.)																						X	X	X		
		PECTORALIS MAJ. (STERN.)																							X	X	X	X
		PECTORALIS MINOR																							(x)	X	X	
Axill. (Circ.)		TERES MINOR																						X				
		DELTOID																						X				
Musc. Cut.		CORACO BRACHIALIS																								X		
		BICEPS																						X	X			
		BRACHIALIS																						X	X			
Radial (Musculo-spiral)		TRICEPS																								X	X	
		ANCONEUS																								X	X	
		BRACHIALIS (SMALL PART)																						X	X			
		BRACHIO-RADIALIS																						X	X			
		EXT. CARPI RAD. L. B.																							X	X		
		SUPINATOR																						(x)	X	(x)		
		EXT. DIGITORUM COMMUNIS																						(x)	X			
		EXT. MINIMI DIGITI																								X	(x)	
		EXT. CARPI ULNARIS																							( )	X		
		ABD. POLLICIS LONGUS																							(x)	X		
		EXT. POLLICIS BREVIS																							(x)	X		
		EXT. POLLICIS LONGUS																							(x)	X		
		EXT. INDICIS																							(x)	X		
Median		PRONATOR TERES																							X			
		FLEX. CARPI RADIALIS																							X		(x)	
		PALMARIS LONGUS																							(x)			
		FLEX. DIGITORUM SUBLIMIS																								X	X	X
		FLEX. DIGIT. PROF. I II																									X	X
		FLEX. POLLICIS LONGUS																							(x)		X	X
		PRON. QUADRATUS																									X	X
		ABD. POLLICIS BREVIS																									(x)	( )
		OPPONENS POLLICIS																										
		FLEX. POLL. BREV. (SUP. H.)																										
		LUMBRICALES I II																										
Ulnar		FLEX. CARPI ULNARIS																									X	(x)
		FLEX. DIGIT. PROF. III IV																									X	X
		PALMARIS BREVIS																										X
		ABD. MINIMI DIGITI																								( )	X	X
		OPPONENS MINIMI DIGITI																								(x)	X	X
		FLEX. MINIMI DIGITI																								( )	X	X
		LUMBRICALES III IV																								( )	X	X
		DORSAL INTEROSSEI																									X	
		PALMAR INTEROSSEI																									X	
		ADDUCTOR POLLICIS																								(x)	X	
		FLEX. POLL. BREV. (DEEP H.)																									X	(x)

SENSORY



Right Anterior or Left Posterior

Left Anterior or Right Posterior

Children's Hospital School, Balto., Md.

Chart 1

SPINAL MOTOR NERVE & ANATOMICAL MOTOR POINT CHART

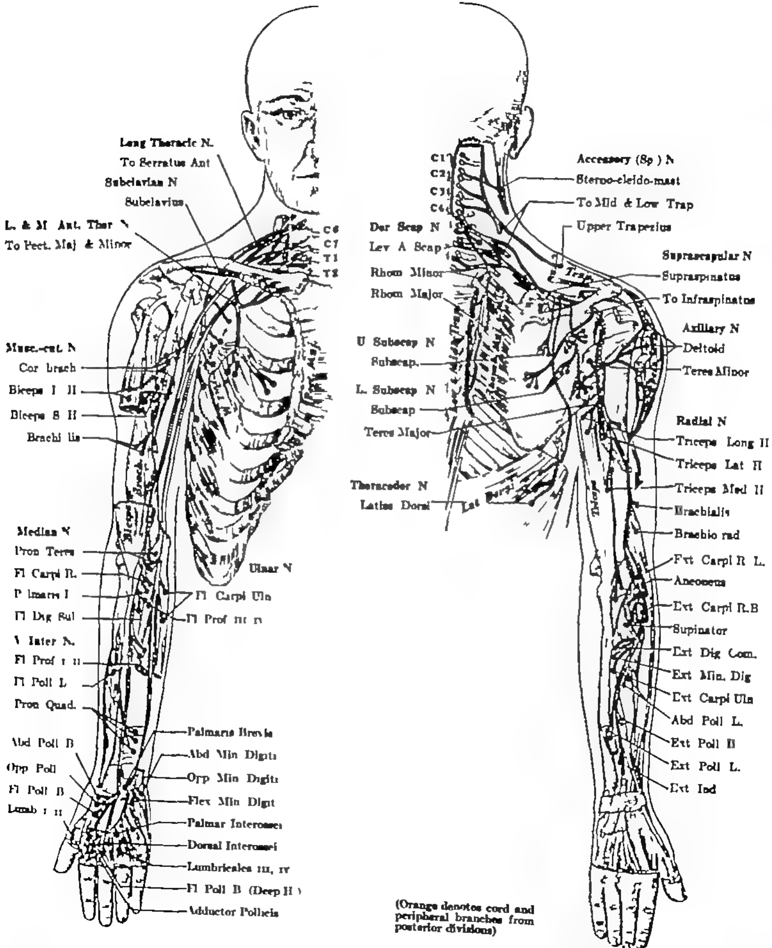


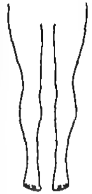
CHART 2

DIAGNOSTIC CHART FOR NERVE LESIONS
TRUNK AND LOWER EXTREMITY

Name ______________________________ *Date* ____________

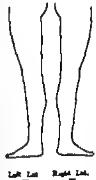
Nerve	Nom. Stren. Grade	Muscle	T 1-12, L 1-4, S 1-4, Dorsal	Ventral Division T1, 2, 3, 4	T5, 6	T7, 8	T9, 10, 11	Iliohypogastric (T12, L1)	Ilioinguinal (T12, L1)	Lumb. Plex. (T12, L1-4 V)	Obturator (L2, 3, 4 Vent.)	Femoral (L2, 3, 4 Dorsal)	Sup. Gluteal (L4, 5, S1 D)	Inf. Gluteal (L4, 5, S1, 2 D)	Sac. Plex. (L4, 5, S1, 2, 3)	Sciatic (L4, 5, S1, 2, 3) D & V	Tibial (L4, 5, S1, 2, 3)	Peroneal (L4, 5, S1, 2 D)	Thoracic T 1, 2, 3, 4	T 5, 6	T 7, 8	T 9, 10	T 11	Lumbar L 1	L 2	L 3	L 4	L 5	Sacral S 1	S 2	S 3
		ERECTOR SPINAE	X																X	X	X	X	X	X	X	X	X	X	X	X	X
Thoracic Nerves		SERRATUS POST. SUP.																	X												
		TRANS. THORACIS			X															X											
		INT. INTERCOSTALS		X	X	X	X												X	X	X	X									
		EXT. INTERCOSTALS		X	X	X	X													X	X	X									
		SUBCOSTALES		X	X														X	X											
		LEVATOR COST. BREV.		X	X	X	X													X	X	X									
		EXTERNAL OBLIQUE			X	X	X													X	X	X									
		RECTUS ABDOMINIS				X	X														X	X									
		INTERNAL OBLIQUE				X	X		(x)												X	X	X	X							
		TRANS. ABDOMINIS				X	X														X	X	X	X							
		SERRATUS POST. INF.					X															X									
Lumb. Plexus		QUADRATUS LUMBORUM																					X	X	X						
		PSOAS MINOR																						X							
		PSOAS MAJOR																							X	X					
Obturator Ant.		ADDUCTOR BREVIS																							X	X	X				
		ADDUCTOR LONGUS																							X	X					
		GRACILIS																							X	X	X				
Obturator Post.		OBTURATOR EXTERNUS																								X	X				
		ADDUCTOR MAGNUS														x										X	X				
Femoral		ILIACUS																							X	X					
		PECTINEUS									( )														X	X					
		SARTORIUS																							X	X	(x)				
		QUADRICEPS																								X	X				
Sup. Glut.		GLUTEUS MEDIUS																									X	X	X		
		GLUTEUS MINIMUS																									X	X	X		
		TENSOR FASCIA LAT.																									X	X	X		
Inf. Gl.		GLUTEUS MAXIMUS																										X	X	X	
Sacral Plexus		QUADRATUS FEMORIS																									X	X	X		
		GEMELLUS INFERIOR																										X	X	(x)	
		GEMELLUS SUPERIOR																									x	X	X	X	(x)
		OBTURATOR INTERNUS																										X	X	X	(x)
		PIRIFORMIS																											X	X	(x)
Sciatic T. bal		SEMI-TENDINOSUS														x												X	X	X	
		BICEPS (LONG HEAD)																										X	X	X	
		SEMI-MEMBRANOSUS																									X	X	X		
Sciatic P.		BICEPS (SHORT HEAD)																									(x)		X	X	
Tibial (Internal Popliteal) T. bal		GASTROCNEMIUS															x												X	X	
		PLANTARIS																										X	X	(x)	
		POPLITEUS															x										X	X	X		
		SOLEUS																											X	X	
		TIBIALIS POSTICUS																									(x)	X	X	( )	
		FLEX. DIGIT. LONG.																										X	X	x	
		FLEX. HALL. LONG.																										X	X	X	
Med. Pl.		FLEX. DIGIT. BREVIS																										X	X		
		ABDUCTOR HALLUCIS																										X	X		
		FLEX. HALL. BREVIS																										X	X	( )	
		I. LUMBRICALIS ( )																										X	X		
Lat. Plant.		ABD. DIGITI QUINTI																										(x)	X	X	(x)
		QUADRATUS PLANT.																										(x	X	X	( )
		FLEX. DIGITI QUINTI																										( )	X		(x)
		OPP. DIGITI QUINTI																											x	X	(x)
		ADDUCTOR HALLUCIS																											X	X	( )
		PLANTAR INTEROSSEI																											X	X	(x)
		DORSAL INTEROSSEI																											X	X	(x)
		LUMBRICALES (, IV)																										( )	X	X	(
Peroneal (Ext. Pop.) Sup.		PERONEUS LONGUS																x										X	X	(x)	
		PERONEUS BREVIS																										X	(x)		
Deep		TIBIALIS ANTICUS																									X	X			
		EXT. DIGIT. LONG.																x									X	X	X	( )	
		PERONEUS TERTIUS																									X	X	X		
		EXT. HALL. LONG.																										X	X	( )	
		EXT. DIGIT. BREVIS																										X		( )	

History



Left Post. or Right Ant. — Right Post. or Left Ant.

(Draw in lead outline for Posterior View)



Left Lat. or Right Med. — Right Lat. or Left Med.

© [illegible] Baltimore [illegible] — [illegible]

CHART 3

SPINAL MOTOR NERVE AND ANATOMICAL MOTOR POINT CHART

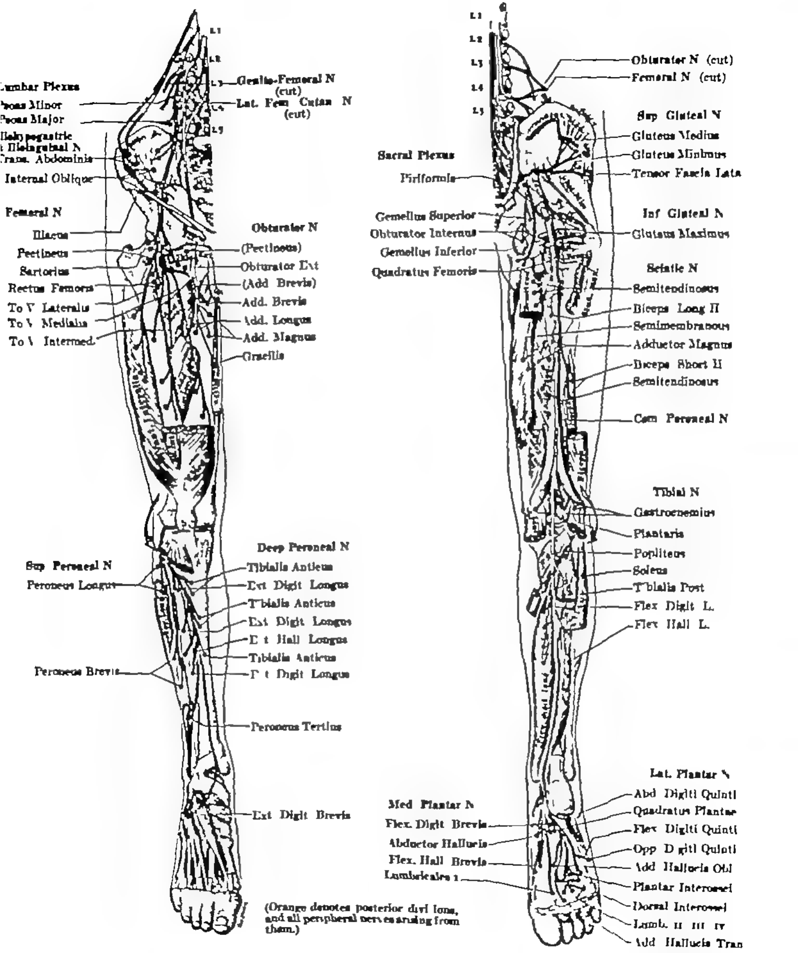


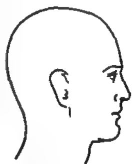
CHART 4

CRANIAL NERVE CHART

Name ______________ Date ______

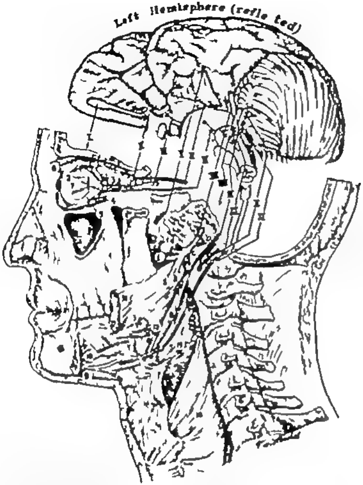
			SENSORY OR MOTOR TO:	S I Olfactory	S II Optic	M III Oculomotor	M IV Trochlear	S & M V Trigeminal	M VI Abducens	S & M VII Facial	S VIII Auditory	S & M IX Glossopharyngeal	S & M X Vagus	M XI Accessory	M XII Hypoglossal
	NOSE		SENSORY—SMELL												
II	EYE		SENSORY—SIGHT												
	EYELID		LEVATOR PALPEBRAE SUPERIORIS												
			RECTUS SUPERIOR												
III	EYE		OBLIQUUS INFERIOR												
			RECTUS MEDIALIS												
			RECTUS INFERIOR												
	EYE		OBLIQUUS SUPERIOR												
			SENSORY—FACE, FOREPART OF HEAD												
	Mandible		MASSETER												
			TEMPORALIS												
			PTERYGOIDEUS INTERNUS												
			PTERYGOIDEUS EXTERNUS												
	H. HYOID		MYLOHYOIDEUS												
	S. HYOID		ANTERIOR DIGASTRIC												
VI	EYE		RECTUS LATERALIS												
	TONGUE		SENSORY—TASTE, ANT. ⅔ TONGUE												
	EAR		SENSORY—MIDDLE EAR												
	SCALP		OCCIPITALIS												
	EAR		INTRINSIC EAR MUSCLES												
	EAR		STAPEDIUS												
	EAR		AURICULARIS POSTERIOR												
	HYOID		POSTERIOR DIGASTRIC												
	HYOID		STYLOHYOIDEUS												
	EAR		AURICULARIS ANTERIOR												
	EAR		AURICULARIS SUPERIOR												
	FOREHEAD		FRONTALIS												
	EYEBROW		CORRUGATOR												
	EYELID		ORBICULARIS OCULI												
VII	MOUTH		BUCCINATOR												
	MOUTH		ORBICULARIS ORIS												
	MOUTH		ZYGOMATICUS												
	NOSE		PROCERUS												
	NOSE		DEPRESSOR SEPTI												
	NOSE		NASALIS TRANSVERSUS ALAE												
	NOSE		DILATOR NARIS ANT. & POST.												
	MOUTH		QUADRATUS LABII SUPERIORIS												
	MOUTH		CANINUS												
	MOUTH		RISORIUS												
	CHIN		MENTALIS												
	MOUTH		TRIANG. LABII												
	MOUTH		QUADRATUS LABII INFERIORIS												
	NECK		PLATYSMA												
VIII	EAR		SENSORY—HEARING & EQUILIBRIUM												
	TONGUE		SENSORY—POSTERIOR ⅓ TONGUE												
IX	THROAT		SENSORY—PHARYNX, UVULA, PALATINE TONSIL												
	PHARYNX		STYLOPHARYNGEUS												
	PALATE		VOLUNTARY MUSCLES—SOFT PALATE												
	LARYNX		VOLUNTARY MUSCLES—LARYNX												
	—	—	INVOLUNTARY MUSCLES—ALIMENTARY TRACT												
		—	INVOLUNTARY MUSCLES—AIR PASSAGES												
	—	—	INVOLUNTARY CARDIAC MUSCLES												
	—		SENSORY—MENINGEAL												
	—		SENSORY—AURICULAR												
	—		SENSORY—ALIMENTARY TRACT												
	—		SENSORY—AIR PASSAGES												
	—		SENSORY—CARDIAC, CELIAC, HEPATIC												
	NECK		TRAPEZIUS												
XI	PALATE		MUSCULUS UVULAE												
	PALATE		LEVATOR VELI PALATINI												
	TONGUE		STYLOGLOSSUS												
	TONGUE		HYOGLOSSUS												
XII	TONGUE		GENIOGLOSSUS												
	I. HYOID		GENIOHYOIDEUS												

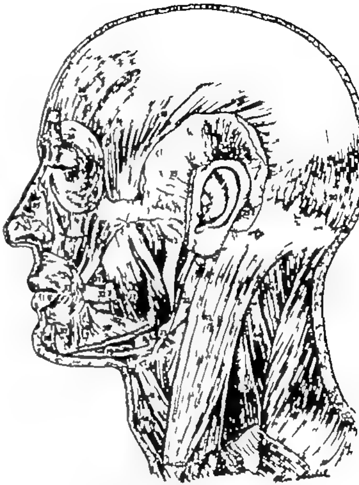
SENSORY



[illegible]   [illegible]

Chart 5





I Olfactory (Sensory)
II Optic (Sensory)
VIII Auditory (Sensory)
III Oculomotor
  Levator Pal Sup (1)
  Rectus Sup (2)
  Rectus Med (3)
  Rectus Inf (4)
  Obliquus Inf (5)
IV Trochlear
  Obliquus Sup (6)
VI Abducens
  Rectus Lat. (7)
IX Glossopharyngeal
  Stylopharyngeus (8)

XII Hypoglossal
  Geniohyoideus (9)
  Genioglossus (10)
  Hyoglossus (11)
  Styloglossus (12)
V Trigeminal, Mand. Br
(a) Motor Portion to:
  Masseter (17)
  Temporalis (18)
  Ant Digastric (19)
  Pterygoid Int
  Pterygoid Ext.
  Mylohyoideus
  Tensor Tympani
  Tensor Veli Palat.

VII Facial
(b) Post. Auric Br to:
  Occipitalis (20)
  Auric Post (21)
(c) Branch to:
  Post Digast (22)
  Stylohyoideus (23)
(d) Temporal Br to:
  Auric Sup (24)
  Auric Ant (25)
  Frontalis (26)
  Corrugator (27)
  Orbicul Oculi (28)
(e) Zygomatic Br to:
  Orbicul Oculi (28)

(f) Buccal Branch to:
  Quad Labii Sup (29)
  Zygomaticus (30)
  Buccinator (31)
  Risorius (32)
  Orbicularis Oris (33)
  Caninus
  Procerus (34)
  Nasalis (35)
(g) Mandibular Br to:
  Mentalis (36)
  Quad Labii Inf (37)
  Triangularis (38)
(h) Cervical Branch to:
  Platysma (39)

X Vagus
XI Accessory
  Sterno-cl mast (42)
  Trapezius (46)
Pharyngeal Plexus (IX & X)
  Glossopalatini (13)
  Sup Phar Const (14)
  Med Phar Const (15)
  Inf Phar Const (16)
Misc from Cerv Nerves
  Sternohyoid (40)
  Omohyoid (41)
  Scalenus Med (43)
  Lev Ang. Scap. (44)
  Splenius Cap (45)

CHART 6

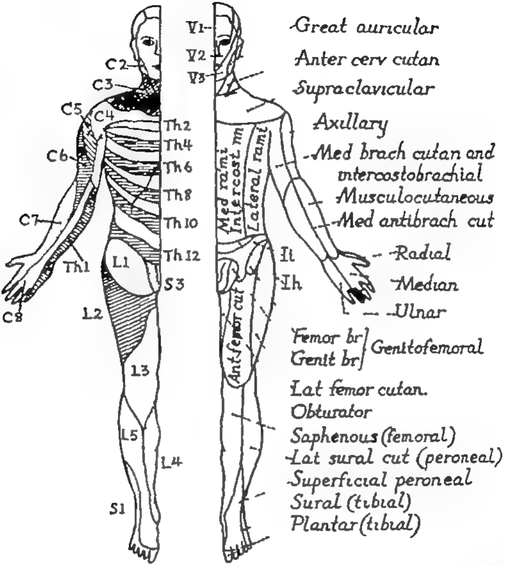


CHART 7

Dermatomes (left) and cutaneous fields of peripheral nerves Front view Ih iliohypogastric Il ilioinguinal (From Strong and Elwyn Human Neuroanatomy The Williams & Wilkins Company 1948)

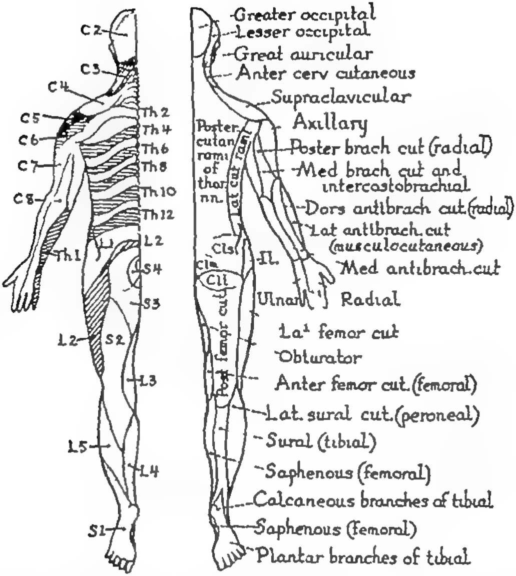


CHART 8

Dermatomes (left) and cutaneous fields of peripheral nerves. Back view. Cls, Clm, Cli, superior medial, and inferior clunial nerves. Il. iliohypogastric nerve. (From Strong & Elwyn, Human Neuroanatomy. The Williams & Wilkins Company, 1948.)

DIAGNOSTIC CHART FOR NERVE LESIONS
UPPER EXTREMITY

Name: O. H. S.   Date: September 19, 1947

MOTOR — Right Arm

Region	Mus. Strength Grade	Muscle	C1	C2	C3	C4	C5	C6	C7	C8	T1
Cervical Nerves		Cervical Extensor Spinae	X	X	X	X	X	X	X	X	X
		Infra-hyoid muscles	X	X	X						
		Rectus cap. ant. & lat.	X	X							
		Longus capitis	X	X	X						
		Longus colli		X	X	X	X	X	(X)		
		Levator scapulae			X	X	X				
		Scaleni (A. M. P.)			(X)	X	X	X	X		
		Sterno-cleido mastoid	(X)	X	X						
		Trapezius (U. M. L.)		X	X	X					
		Diaphragm			X	X	X				
Brachial Plexus		Serratus anterior					X	X	X		
		Rhomboids, maj. & minor				(X)	X				
		Subclavius					X	X			
		Supra-spinatus					X				
		Infra-spinatus					X	X			
		Subscapularis					X	X			
		Latissimus dorsi						X	X	X	
		Teres major						X			
		Pectoralis maj. (clav.)					X	X	X		
		Pectoralis maj. (stern.)						X	X	X	X
		Pectoralis minor						(X)	X	X	
Axil. (Circ.)		Teres minor									
	[illegible]	Deltoid					X				
Mus. Cut.	—	Coraco-brachialis							X		
	[illegible]	Biceps					X	X			
	—	Brachialis					X	X			
Radial (and posterior interosseous)	[illegible]	Triceps							X	X	
	—	Anconeus								X	
	—	Brachialis (small part)					(X)	X			
	[illegible]	Brachio-radialis					(X)	X			
	[illegible]	Ext. carpi rad. L. & B.						X	X		
	[illegible]	Supinator					(X)	X			
	[illegible]	Ext. digitorum communis					(X)	X			
	—	Ext. digiti quinti proprius							X		
	[illegible]	Ext. carpi ulnaris						(X)	X		
	[illegible]	Abd. pollicis longus						(X)	X		
	[illegible]	Ext. pollicis brevis						(X)	X		
	[illegible]	Ext. pollicis longus						(X)	X		
	—	Ext. indicis						(X)	X		
Median	[illegible]	Pronator teres						X			
	[illegible]	Flex. carpi radialis						X		(X)	
	—	Palmaris longus									
	[illegible]	Flex. digitorum sublimis							(X)	X	X
	[illegible]	Flex. digit. prof. I & II								X	X
	[illegible]	Flex. pollicis longus						(X)		(X)	X
	[illegible]	Pronator quadratus						(X)		X	X
	[illegible]	Abd. pollicis brevis									(X)
	[illegible]	Opponens pollicis									
	[illegible]	Flex. poll. brev. (sup. h.)									(X)
	[illegible]	Lumbricales I & II									
Ulnar	[illegible]	Flex. carpi ulnaris								X	
	[illegible]	Flex. digit. prof. III & IV								X	X
	—	Palmaris brevis							(X)	X	X
	[illegible]	Abd. digiti quinti							(X)	X	X
	[illegible]	Oppon. digiti quinti							(X)		X
	—	Flex. digiti quinti							(X)		
	[illegible]	Lumbricales III & IV							(X)		X
	[illegible]	Dorsal interossei								X	
	[illegible]	Palmar interossei								X	
	[illegible]	Adductor pollicis								X	
	—	Flex. poll. brev. (deep h.)								X	

SENSORY

Right Anterior

Right Posterior

    Florence P. Kendall, Children's Hospital School, Baltimore, Md.

Chart 9

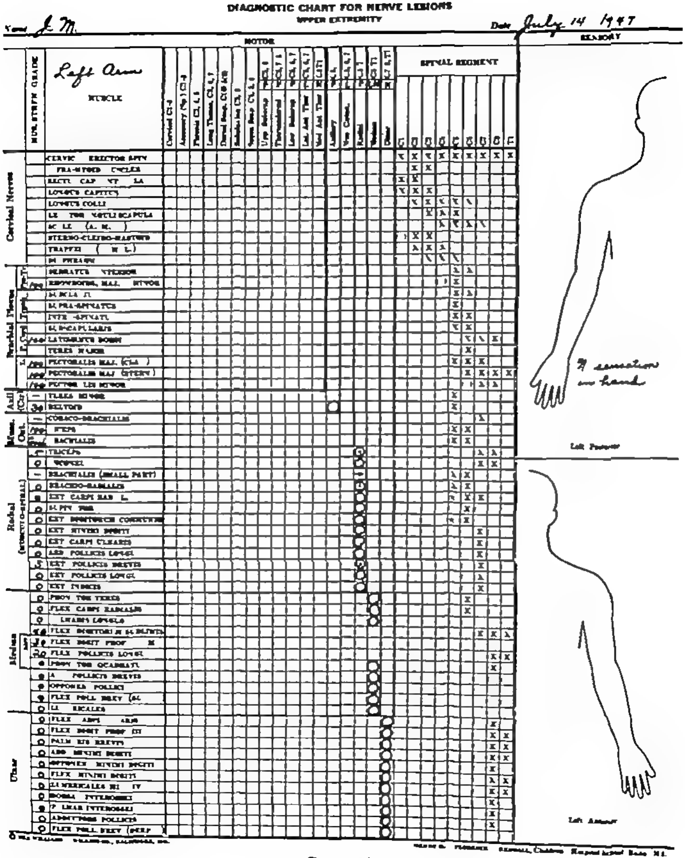

DIAGNOSTIC CHART FOR NERVE LESIONS
UPPER EXTREMITY
Name J. M.
Date July 14 1947
MOTOR
SENSORY
Left Arm
MUSCLE
MUS. STRENGTH GRADE
SPINAL SEGMENT
Cervical Nerves
Brachial Plexus
Radial
Median
Ulnar
No sensation in hand
Left Posterior
Left Anterior

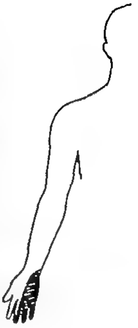
Chart 10

DIAGNOSTIC CHART FOR NERVE LESIONS
UPPER EXTREMITY

Name A. H. S. — Date September 19, 1947

MOTOR — Right Arm — SENSORY

Group	Muscle	C1	C2	C3	C4	C5	C6	C7	C8	T1
Cervical Nerves	Cervical erector spin.	X	X	X	X	X	X	X	X	X
	Infra-hyoid muscles	X	X	X						
	Rectus cap. ant. lat.	X	X							
	Longus capitis	X	X	X						
	Longus colli		X	X	X	X	X	(x)		
	Lev. tor scapulae			X	X	X				
	Scalen. (A. M.)				X	X	X	X		
	Sterno-cleido-mastoid	(x)	X	X						
	Trapezius (M. L.)		X	X	X					
	Diaphragm			X	X	X				
Brachial Plexus	Serratus anterior					X	X	X		
	Rhomboids maj. minor				(x)	X				
	Subclavius					X	X			
	Supra-spinatus					X				
	Infra-spinatus					X	X			
	Subscapularis					X	X			
	Latissimus dorsi						X	X	X	
	Teres major						X			
	Pectoralis maj. (clav.)					X	X	X		
	Pectoralis maj. (stern.)						X	X	X	X
	Pectoralis minor							X	X	
Axil. (Cir.)	Teres minor					X				
	Deltoid					X				
Musc. Cut.	Coraco-brachialis							X		
	Biceps					X	X			
	Brachialis					X	X			
Radial	Triceps							X	X	
	Anconeus							X	X	
	Brachialis (small part)					X	X			
	Brachio-radialis					X	X			
	Ext. carpi rad. L. B.					(x)	X	X		
	Supinator					(x)	X			
	Ext. digitorum commun.					(x)	X			
	Ext. minimi digiti							X		
	Ext. carpi ulnaris							X		
	Abd. pollicis longus						(x)	X		
	Ext. pollicis brevis						(x)	X		
	Ext. pollicis longus						(x)	X		
	Ext. indicis							X		
Median	Pronator teres						X			
	Flex. carpi radialis						X		(x)	
	Palmaris longus									
	Flex. digitorum sublimis									X
	Flex. digit. prof. II								X	
	Flex. pollicis longus									X
	Pronator quadratus								X	X
	Abd. pollicis brevis									
	Oppon. pollicis									
	Flex. poll. brev. (sup. head)									
	Lumbricales II									
Ulnar	Flex. carpi ulnaris									
	Flex. digit. prof. III IV								X	X
	Palmaris brevis									X
	Abd. mi. digiti								X	X
	Oppon. minimi digiti								X	X
	Flex. minimi digiti								X	X
	Lumbricales III IV								X	X
	Dorsal interossei								X	
	Volar interossei								X	
	Adductor pollicis								X	
	Flex. poll. brev. (deep)								X	(x)



Right Anterior

Right Posterior

CHART 9

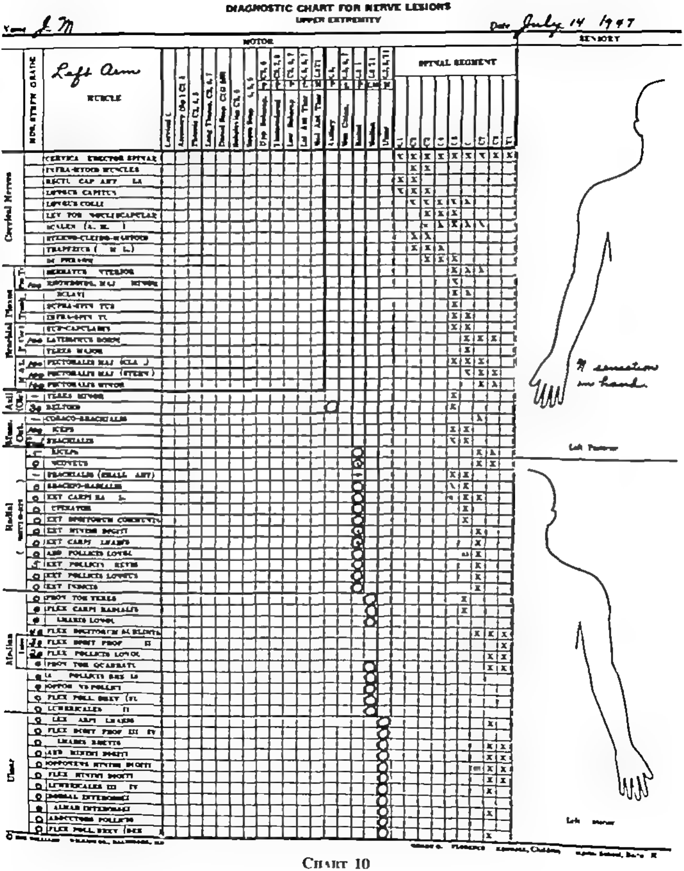

DIAGNOSTIC CHART FOR NERVE LESIONS
UPPER EXTREMITY
Name J. M
Date July 14 1947
MOTOR
SENSORY
Left Arm
MUSCLE
SPINAL SEGMENT
Cervical Nerves
Brachial Plexus
Radial
Median
Ulnar
No sensation in hand
Left Posterior
Left Anterior

CHART 10

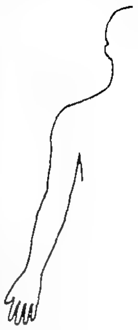
DIAGNOSTIC CHART FOR NERVE LESIONS
UPPER EXTREMITY

Name *M. C.* Date *March 1, 1948*

MOTOR — *Left Arm*

Region	Mus. Stren. Grade	Muscle	Radial	Median	Ulnar	C1	C2	C3	C4	C5	C6	C7	C8	T1
Cervical Nerves		CERVICAL ERECTOR SPINAE				X	X	X	X	X	X	X	X	X
		INFRA-HYOID MUSCLES				X	X	X						
		RECTUS CAP. ANT. ET LAT.				X	X							
		LONGUS CAPITIS				X	X	X						
		LONGUS COLLI					X	X	X	X	X	( )		
		LEVATOR SCAPULAE						X	X	X				
		SCALENI (A. M. P.)						X	X	X	X	X		
		STERNO-CLEIDO-MASTOID				( )	X	X						
	100	TRAPEZIUS (U. M. L.)					X	X	X					
		DIAPHRAGM						X	X	X				
Brachial Plexus	100	SERRATUS ANTERIOR								X	X	X		
	100	RHOMBOIDS, MAJ. & MINOR							( )	X				
	—	SUBCLAVIUS								X	X			
	N	SUPRA-SPINATUS								X				
	100	INFRA-SPINATUS								X	X			
	100	SUBSCAPULARIS								X	X			
	100	LATISSIMUS DORSI									X	X	X	
	100	TERES MAJOR									X			
	100	PECTORALIS MAJ. (CLA.)								X	X	X		
	100	PECTORALIS MAJ. (STERN.)									X	X	X	X
	100	PECTORALIS MINOR									(X)	X	X	
Axill. (Circ.)	100	TERES MINOR								X				
	90	DELTOID *Shoulder is painful when continuous pressure applied*								X				
Mus. Cut.	N	CORACO-BRACHIALIS										X		
	100	BICEPS								X	X			
		BRACHIALIS								X	X			
	100	TRICEPS *100*										X	X	
	90	ANCONEUS										X	X	
Radial (Musculo Spiral)	—	BRACHIALIS (SMALL PART)								X	X			
	0	BRACHIO-RADIALIS	O							X	X			
	0	EXT. CARPI RAD. L. & B.	O								X	X		
	0	SUPINATOR	O							X	X	(X)		
	0	EXT. DIGITORUM COMMUNIS	O								X			
	0	EXT. DIGITI QUINTI	O									X		
	0	EXT. CARPI ULNARIS	O								(X)	X		
	0	ABD. POLLICIS LONGUS	O								(X)	X		
	0	EXT. POLLICIS BREVIS	O								(X)	X		
	0	EXT. POLLICIS LONGUS	O								( )	X		
	0	EXT. INDICIS	O								(X)	X		
Median	60	PRONATOR TERES		O							X			
	60	FLEX. CARPI RADIALIS		O							X		( )	
		PALMARIS LONGUS		O							(X)			
	60	FLEX. DIGITORUM SUBLIMIS		O								X	X	X
	0	FLEX. DIGIT. PROF. I II		O									X	X
	60	FLEX. POLLICIS LONGUS		O							(X)		X	
	—	PRON. TOR. QUADRATUS		O							( )		X	X
	30	ABD. POLLICIS BREVIS		O									( )	X
	60	OPPONENS POLLICIS		O										X
	50	FLEX. POLL. BREV. (SUP.)		O										X
	30	LUMBRICALES I II		O										
Ulnar	60	FLEX. CARPI ULNARIS			O								X	
	70	FLEX. DIGIT. PROF. III IV			O								X	
	—	PALMARIS BREVIS			O							( )	X	X
	5	ABD. DIGITI QUINTI			O							( )	X	X
	P	OPPONENS DIGITI QUINTI			O							( )	X	X
	—	FLEX. DIGITI QUINTI			O							(X)	X	X
	30	LUMBRICALES III IV			O							(X)	X	X
	30	DORSAL INTEROSSEI			O								X	
	30	PALMAR INTEROSSEI			O								X	
	0	ADDUCTOR POLLICIS			O							(X)	X	
	—	FLEX. POLL. BREV. (DEEP H.)			O								X	(X)

SENSORY



Right Anterior
Left Posterior

Left Anterior
Right Posterior

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CHART 11

DIAGNOSTIC CHART FOR NERVE LESIONS
UPPER EXTREMITY

Name J. W.   Date April 26, 1948.

MOTOR   SENSORY

Nerve	Muscle Strength Grade	Muscle
Cervical Nerves		Cervical Extensor group
		Infra-hyoid muscles
		Rectus cap. ant. & lat.
		Longus capitis
		Longus colli
		Levator scapulae
		Scaleni ( )
		Sterno-cleido-mastoid
		Trapezius ( )
		Diaphragm
Brachial Plexus	App	Serratus anterior
		Rhomboids, maj. & minor
		Subclavius
		Supraspinatus
		Infraspinatus
		Subscapularis
		Latissimus dorsi
		Teres major
	App	Pectoralis maj. (clav.)
	App	Pectoralis maj. (stern.)
		Pectoralis minor
Axil.		Teres minor
	Zero	Deltoid
Musc. Cut.	App	Coraco-brachialis
	Fr	Biceps
	—	Brachialis
Radial	→	Triceps — Long head good, but l. and med. heads weak
	—	Anconeus
	—	Brachialis (small part)
	20	Brachio-radialis
	30	Ext. carpi rad. l.
	—	Supinator
	30	Ext. digitorum communis
	—	Ext. digiti minimi
	20	Ext. carpi ulnaris
	40	Abd. pollicis longus
	40	Ext. pollicis brevis
	30	Ext. pollicis longus
	—	Ext. indicis
Median	20	Pronator teres
	20	Flex. carpi radialis
	10	Palmaris longus
	40	Flex. digitorum sublimis
	20	Flex. digit. prof. I, II
	60	Flex. pollicis longus
	—	Pronator quadratus
	0	Abd. pollicis brevis
	0	Opponens pollicis
	0	Flex. poll. brev. (sup.)
	0	Lumbricales I, II
Ulnar	5	Flex. carpi uln.
	20	Flex. digit. prof. III, IV
	—	Palmaris brevis
	0	Abd. digiti minimi
	0	Opponens digiti minimi
	—	Flex. digiti minimi
	0	Lumbricales III, IV
	0	Dorsal interossei
	0	Palmar interossei
	0	Adductor pollicis
	0	Flex. poll. brev. (deep)


Right Anterior or Left Posterior


Left Anterior or Right Posterior

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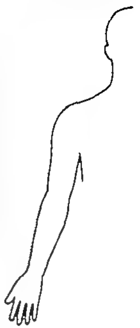
CHART 12

Name M. C. — DIAGNOSTIC CHART FOR NERVE LESIONS — UPPER EXTREMITY — Date March 1, 1948

MOTOR — SENSORY

Left Arm

Nerve	Mus. Stren. Grade	Muscle
Cervical Nerves		CERVICAL ERECTOR SPINAE
		PRE-HYOID MUSCLES
		RECTUS CA. ANT. LA.
		LONGUS CAPITIS
		LONGUS COLLI
		LEV. TOR. SCAPULA
		SCALENI ( )
		STERNO-CLEIDO-MASTOID
	[illegible]	TRAPEZIUS (U. M. L.)
		DIAPHRAGM
Brachial Plexus	[illegible]	SERRATUS ANTERIOR
	[illegible]	RHOMBOIDS, MAJ. MINOR
	—	SUBCLAVIUS
	N	SUPRA SPINATUS
	[illegible]	INFRA-SPIN. TOR.
	[illegible]	SUBSCAPULARIS
	[illegible]	LATISSIMUS DORSI
	[illegible]	TERES MAJOR
	[illegible]	PECTORALIS MAJ. (CLA.)
	[illegible]	PECTORALIS MAJ. (STERN.)
	[illegible]	PECTORALIS MINOR
Axil. (Cir.)	[illegible]	TERES MINOR
	[illegible]	DELTOID Shoulder is painful when motion / pressure is applied
Mus. Cut.	N	CORACO-BRACHIALIS
	[illegible]	BICEPS
	[illegible]	BRACHIALIS
Radial (Musculo-spiral)	[illegible]	TRICEPS (? ?
		ANCONEUS 0 ?
	—	BRACHIALIS (SMALL ANT.)
	0	BRACHIO-RADIALIS
	0	EXT. CARPI RAD. L.
	0	SUPIN. TOR.
	0	EXT. DIGITORUM COMMUNIS
	0	EXT. MINIMI DIGITI
	0	EXT. CARPI ULNARIS
	0	ABD. POLLICIS LONGUS
	0	EXT. POLLICIS BREVIS
	0	EXT. POLLICIS LONGUS
	0	EXT. INDICIS
Median	[illegible]	PRONATOR TERES
	[illegible]	FLEX. CARPI RADIALIS
	[illegible]	PALMARIS LONGUS
	[illegible]	FLEX. DIGITORUM SUBLIMIS
	[illegible]	FLEX. DIGIT. PROF. I II
	[illegible]	FLEX. POLLICIS LONGUS
	—	PRON. TOR. QUADRATUS
	[illegible]	ABD. POLLICIS BREVIS
	[illegible]	OPPONENS POLLICIS
	[illegible]	FLEX. POLL. BREV. (SUP. H.)
	[illegible]	LUMBRICALES
Ulnar	[illegible]	FLEX. CARPI ULNARIS
	[illegible]	FLEX. DIGIT. PROF. III IV
	—	PALMARIS BREVIS
	?	ABD. MINIMI DIGITI
	?	OPPONENS MINIMI DIGITI
	—	FLEX. MINIMI DIGITI
	[illegible]	LUMBRICALES III IV
	[illegible]	DORSAL INTEROSSEI
	[illegible]	PALMAR INTEROSSEI
	[illegible]	ADDUCTORS POLLICIS
	—	FLEX. POLL. BREV. (DEEP H.)



Right Anterior — Left Posterior

Left Anterior — Right Posterior

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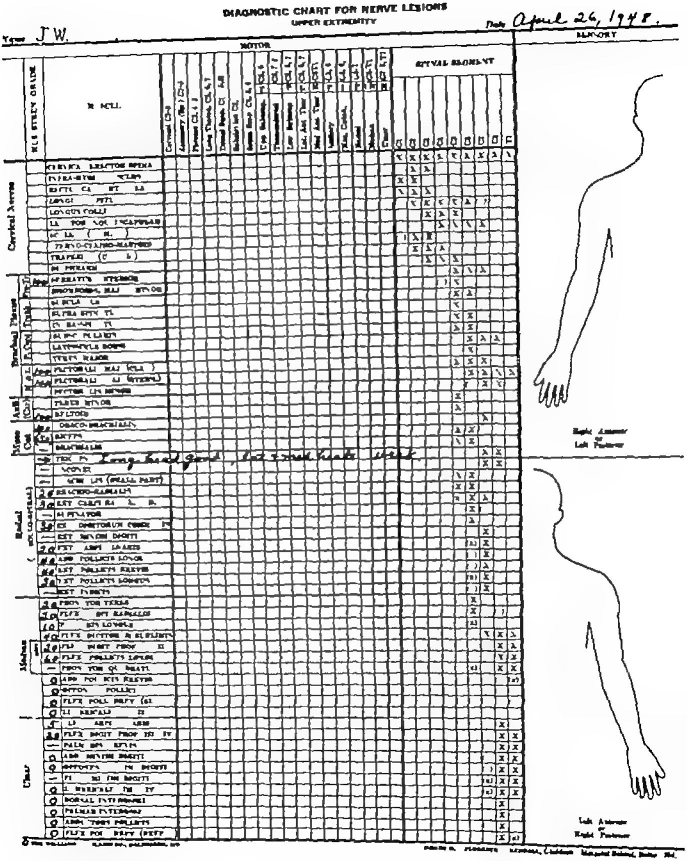
CHART 11



DIAGNOSTIC CHART FOR NERVE LESIONS

UPPER EXTREMITY

Name J. W.

Date April 26, 1948.

MOTOR

SPINAL SEGMENT

SENSORY

Cervical Nerves

Brachial Plexus

Radial

Median

Ulnar

TRICEPS Long head good, but small heads weak

Right Anterior or Left Posterior

Left Anterior or Right Posterior

CHART 12

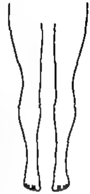
DIAGNOSTIC CHART FOR NERVE LESIONS
TRUNK AND LOWER EXTREMITY

Name C 2 — Date January 29, 1948

Left Leg

Nerve	Mus. Strgth. Grade	Muscle	T 1-12, L 1-4, S 1-3 Dorsal	Intercostal T 1,2,3,4	T 5,6	T 7,8	T 9,10	T 1,2,3	T 4,5	T 7,8	T 9,10,11	T 12	L 1	L 2	L 3	L 4	L 5	S 1	S 2	S 3
		Erector spinae	X					X	X	X	X	X	X	X	X	X	X	X	X	X
Thoracic Nerves		Serratus post. sup.		X				X												
		Trans. thoracis			X				X											
		Int. intercostales		X	X	X	X	X	X	X	X									
		Ext. intercostales		X	X	X	X	X	X	X	X									
		Subcostales		X	X			X	X											
		Lev. costarum		X	X	X	X		X	X	X									
		External oblique			X	X	X		X	X	X									
		Rectus abdominis				X	X			X	X									
		Internal oblique				X	X			X	X	X	X							
		Transversus abd.				X	X			X	X	X	X							
		Serratus post. inf.					X				X									
Lumb. Plexus		Quadratus lumborum										X	X	X						
		Psoas minor											X	X						
	100	Psoas major												X	X					
Obturator Ant.	80	Adductor brevis												X	X	X				
		Adductor longus												X	X					
		Gracilis												X	X	X				
Obturator Post.		Obturator externus													X	X				
		Adductor magnus													X	X				
Femoral	100	Iliacus												X	X					
	—	Pectineus												X	X					
	100	Sartorius												X	X	(X)				
	100	Quadriceps													X	X				
Sup. Glut.	70	Gluteus medius														X	X	X		
	70	Gluteus minimus														X	X	X		
	70	Tensor fasciae lat.														X	X	X		
Inf. Glut.	70	Gluteus maximus															X	X	X	
Sacral Plexus	60	Quadratus femoris														X	X	X		
		Gemellus inferior															X	X	(X)	
		Gemellus superior														(X)	X	X	X	(X)
		Obturator internus															X	X	X	
		Piriformis																X	X	(X)
Sciatic Tibial	70	Semitendinosus															X	X	X	
	60	Biceps (long head)															X	X	X	
	70	Semimembranosus														X	X	X		
Sciatic Per.	60	Biceps (short head)														(X)		X	X	
Tibial	P	Gastrocnemius (Tendon has been lengthened.)																X	X	
	—	Plantaris															X	X	(X)	
	—	Popliteus														X	X	X		
		Soleus (Tendon has been lengthened.)																X	X	
	0	Tibialis posticus														(X)	X	X	(X)	
	0	Flex. digit. long.															X	X	X	
	0	Flex. hall. long.															X	X	X	
Tibial (Internal Popliteal) Med. Pl.	0	Flex. digit. brevis															X	X		
	0	Abductor hallucis															X	X		
	0	Flex. hall. brevis															X	X		
	0	Lumbricales ( )															X	X		
Lat. Plant.	—	Abd. digiti quinti															( )	X	X	(X)
	—	Quadratus plantae																X	X	(X)
	—	Flex. digiti quinti															(X)	X	(X)	(X)
	—	Opp. digiti quinti																(X)	(X)	(X)
	—	Adductor hallucis																X	X	(X)
	—	Plant. interossei																X	X	( )
	—	Dorsal interossei																X	X	(X)
	0	Lumbricales (,)															(X)	X	X	
Peroneal (Ext. Pop.) Sup.	60	Peroneus longus															X	X	(X)	
	60	Peroneus brevis															X	X	(X)	
Deep	60	Tibialis anticus														X	X			
	60	Ext. digit. long.																X		
	60	Peroneus tertius														X	X	X		
	0	Ext. hall. long.															X			
	0	Ext. digit. brevis																		

SENSORY



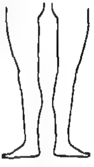


Chart 13

CHILDREN'S HOSPITAL SCHOOL

Respiratory Muscle Chart

Patient's Name ______________________ Clinic # ______________

Examiner / Date								
	Left	Right	Left	Right	Left	Right	Left	Right
INSPIRATORY MUSCLES								
Primary								
Diaphragm								
Levator Costarum								
E ternal Intercostals								
Accessory								
Scaleni								
Sterno-cleido mastoid								
Trapez us								
Serratus Anterior								
Pectorals								
(Latissimus Dorsi)								
Dorsal Spine Extensors								
EXPIRATORY MUSCLES								
Primary								
Abdominal Muscles								
Internal Oblique								
External Obl que								
Rectus Abdominis								
Transversus Abd								
Internal Intercostals								
Transversus Thoracis								
Accessory								
Latissimus Dorsi								
Serratus Post Inf								
Quadratus Lumborum								
Iliocostalis Lumb								

Notes ____

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CHART 14

CHILDREN'S HOSPITAL SCHOOL

ABDOMINAL MUSCLE CHART

Name ____ Clinic No. ____________

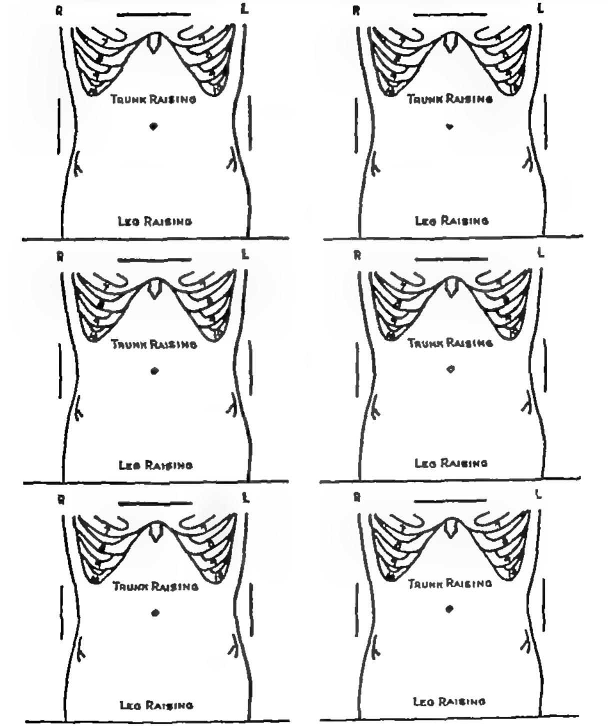

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Chart 17

CHILDREN'S HOSPITAL SCHOOL

ABDOMINAL MUSCLE CHART

Name *Mrs. R. B.* Clinic No.

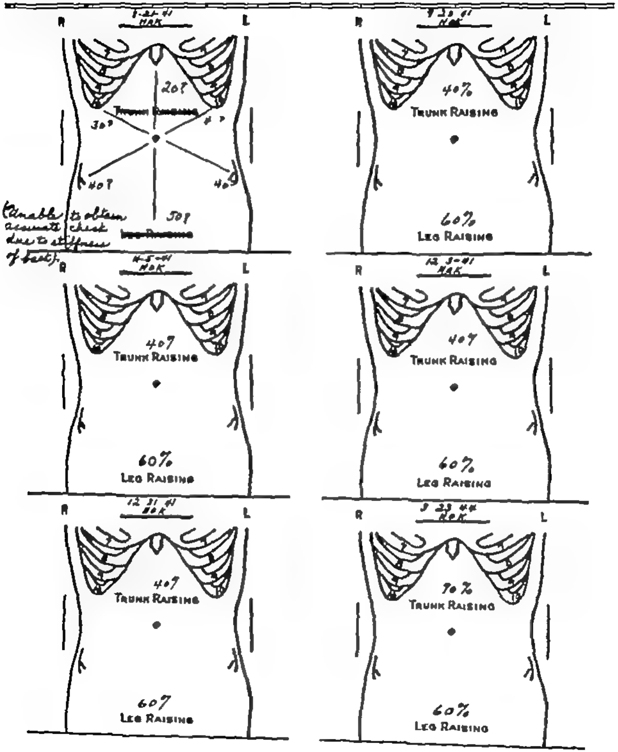

Chart 18

CHILDREN'S HOSPITAL SCHOOL

PATIENT'S NAME J. P. CLINIC No.

MUSCLE CHART No. 2

LEFT [illegible] M.K.	[illegible] M.K.	[illegible] M.K.	[illegible] M.K.	[illegible] M.K.	[illegible] M.K.		RIGHT [illegible] M.K.	[illegible] M.K.	[illegible] M.K.	[illegible] M.K.	[illegible] M.K.	[illegible] M.K.
—	—	—	—	—	—	Facial	—	—	—	—	—	—
—	—	—	—	—	—	Tongue	—	—	—	—	—	—
—	—	—	—	—	—	Deglutition	—	—	—	—	—	—
—	—	—	—	—	—	Speech	—	—	—	—	—	—
100		100	100	100	60	Anterior Deltoid	10	60	60	65	80	90
100		100	100	100	50	Middle Deltoid	10	60	60	65	65	90
100		80	70	70	40	Posterior Deltoid	10	40	40	45	65	80
100				100	80	Upper Trapezius	70	90				100
80		60		70	40	Middle Trapezius	10	40	50	60	70	70
80		60		60	20	Lower Trapezius	20	40	60	60	60	60
100				80		Serratus Magnus		70				100
100				100	50	Rhomboids	20	60	100	100	100	100
100				—	—	Latissimus Dorsi	—	—				100
100				100	60	Pectoralis Major	40	65	65	70	80	90
100				100	100	Pectoralis Minor	80	100	100	100	100	100
100				80	70	Internal Rotators	60	65	80	80	80	100
100				80	80	External Rotators	60	65	70	80	80	100
100				100	70	Biceps	60	70	80	80	100	100
100				100	70	Triceps	50	70	90	70	80	100
—				—	—	Brachio Radialis	—	—	—	—	—	—
100				100	80	Supinators	60	70		80		100
100				100	90	Pronators	60	70		70		100
100				100	70	Flexor Carpi Radialis	60	100		100		100
100				100	90	Flexor Carpi Ulnaris	80	100		100		100
100				90	70	Extensor Carpi Radialis	60	80		100		100
100				100	80	Extensor Carpi Ulnaris	100	80		100		100
100				100	80	1 Flexor Profundus Digitorum 1	60	80		100		100
100				100	80	2 Flexor Profundus Digitorum 2	60	80		100		100
100				100	80	3 Flexor Profundus Digitorum 3	60	90		100		100
100				100	80	4 Flexor Profundus Digitorum 4	60	90		100		100
100				100	80	1 Flexor Sublimus Digitorum 1	60	80		100		100
100				100	80	2 Flexor Sublimus Digitorum 2	60	90		100		100
100				100	80	3 Flexor Sublimus Digitorum 3	60	100		100		100
100				100	80	4 Flexor Sublimus Digitorum 4	60	100		100		100
100				90	60	1 Finger Extensors 1	80	100		100		100
100				90	60	2 Finger Extensors 2	80	100		100		100
100				90	60	3 Finger Extensors 3	80	100		100		100
100				90	60	4 Finger Extensors 4	80	100		100		100
100				100	70	1 Lumbricales 1	80	100		100		100
100				100	70	2 Lumbricales 2	80	100		100		100
100				90	60	3 Lumbricales 3	80	90		100		100
100				90	60	4 Lumbricales 4	80	80		100		100
100				100	70	Dorsal Interossei	60	100		100		100
100				100	60	Palmar Interossei	60	70		100		100
100				100	100	Opponens Pollicis	60	70		90		100
100				100	90	Adductor Pollicis	80	100		90		100
100				70	60	Abductor Pollicis—Longus	60	70		70		100
100				70	60	Abductor Pollicis—Brevis	60	70		100		100
100				90	80	Thumb Flexors	60	70		90		100
100				80	70	Thumb Extensors	60	80		70		100
						Upper Arm						
						Lower Arm						

	Contractions and Deformities	
	Shoulder	
	Elbow	
	Forearm	
	Wrist	
	Fingers	
	Thumb	

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CHART IV

CHILDREN'S HOSPITAL SCHOOL

PATIENT'S NAME F P CLINIC No.

MUSCLE CHART No. 3

LEFT 4-18-45 HCK	3-8-45 HCK	1-22-45 HCK	12-18-44 HCK	10-18-44 HCK	9-21-44 HCK		RIGHT 9-21-44 HCK	10-18-44 HCK	12-18-44 HCK	1-22-45 HCK	3-8-45 HCK	4-18-45 HCK
	50	40	40	30	10	Anterior Neck	10	30	40	40	40	
	60		60		20	Posterior Neck	20		60	60	60	70
70			40		20	Back	20		40			70
						Quadratus Lumborum						
						Rectus Abdominis						
						External Oblique						
						Internal Oblique						
						Lateral Abdominals						
100	100	60	40	30	10	Gluteus Maximus	50	100	100	100	100	100
60	90	40	30	20	10	Gluteus Medius	30	40	60	70	70	60
60	60	30	30	20	10	Inner Hamstrings	100	100	100	100	100	100
60	40	30	30	5	0	Outer Hamstrings	100	100	100	100	100	100
70	70	60	60	60	20	Internal Rotators		80	80	90	90	
90	90	70	70	60	60	External Rotators		80	80	100	100	
90	90	60	60	40	10	Hip Flexors	30	40	70	90	90	
80	80	80	60	40	10	Sartorius	60	90	100	100	100	100
60	80	60	30	20	10	Hip Abductors	30	60	60	60	70	60
100	90	80	80	60	60	Hip Adductors	60	60	90	70	100	100
80	100	80	80	40	20	Tensor Fasciae Latae	50	60	70	80	100	100
100	100	70	60	60	10	Quadriceps	80	70	70	80	100	100
10	5	5	5	0	5	Soleus	90	100	90	100	100	100
0	0	0	5	0	5	Gastrocnemius	100	100	100	100	100	100
5	5	5	5	5	0	Longus Peroneals Longus	100	100	100	100	100	
5	5	5	5	5	0	Brevis Peroneals Brevis	100	100	100	100	100	
0	0	0	0	0	0	Tertius Tertius	100	100	100	100	100	
10	5	5	5	0	0	Tibialis Posticus	100	100	90	100	90	100
20	20	20	20	5	0	Tibialis Anticus	60	100	100	100	10	
0	0	0	0	0	0	Extensor Proprius Hallucis	100	100	90	10	100	
20	20	0	0	0	0	Flexor Longus Hallucis	60	80	100	100	100	
60	70	10	5	5	5	Flexor Brevis Hallucis	100	100	100	100	100	
0	0	5	0	0	5	1 Extensor Longus Digitorum 1	80	100	100	100	100	
0	0	5	0	0	5	2 Extensor Longus Digitorum 2	80	100	100	100	100	
0	0	5	0	0	5	3 Extensor Longus Digitorum 3	80	100	100	100	100	
0	0	5	0	0	5	4 Extensor Longus Digitorum 4	80	100	100	100	100	
0	0	0	0	0	0	1 Extensor Brevis Digitorum 1	100	100	100	100	100	
0	0	0	0	0	0	2 Extensor Brevis Digitorum 2	100	100	100	100	100	
0	0	0	0	0	0	3 Extensor Brevis Digitorum 3	100	100	100	100	100	
0	0	0	0	0	0	4 Extensor Brevis Digitorum 4	100	100	100	100	100	
40	0	0	0	0	0	1 Flexor Longus Digitorum 1	70	60	90	100	90	
40	0	0	0	0	0	2 Flexor Longus Digitorum 2	70	60	90	100	100	
60	60	0	0	0	0	3 Flexor Longus Digitorum 3	70	60	90	100	100	
60	60	0	0	0	0	4 Flexor Longus Digitorum 4	70	60	90	100	100	
70	60	60	60	60	50	1 Flexor Brevis Digitorum 1	40	70	60	60	80	
60	70	60	60	60	50	2 Flexor Brevis Digitorum 2	40	70	60	70	80	
70	70	60	60	60	40	3 Flexor Brevis Digitorum 3	40	70	60	70	80	
70	70	60	60	60	40	4 Flexor Brevis Digitorum 4	60	70	60	70	80	
70	70	60	40	40	10	1 Lumbricales 1	70	80	90	70	100	
70	70	60	40	40	10	2 Lumbricales 2	70	80	90	70	100	
60	60	60	40	40	10	3 Lumbricales 3	70	60	90	70	100	
60	60	60	40	40	10	4 Lumbricales 4	70	60	90	70	100	
						Length						
						Calf						
						Thigh						

Left	Contractions and Deformities	Right
	Neck	
	Back	
	Hip	
	Knee	
	Ankle	
	Foot	

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CHART 20

CHILDREN'S HOSPITAL SCHOOL

PATIENT'S NAME M. B. CLINIC No. 6694

MUSCLE CHART No. 3

LEFT | RIGHT

Left				Right
6-7-47 HGK				6-7-47 HGK
70		Anterior Neck		70
100		Posterior Neck		100
100		Back		100
—		Quadratus Lumborum		—
		Rectus Abdominis		
		External Oblique		
		Internal Oblique		
		Lateral Abdominals		
55		Gluteus Maximus		55
60		Gluteus Medius		60
70		Inner Hamstrings		60
70		Outer Hamstrings		70
65		Internal Rotators		70
60		External Rotators		60
70		Hip Flexors		80
60		Sartorius		80
60		Hip Abductors		60
70		Hip Adductors		60
60		Tensor Fasciae Latae		80
70		Quadriceps		70
100		Soleus		100
Weak		Gastrocnemius		Weak
20	Longus		Longus	55
20	Brevis	Peroneals	Brevis	55
10	Tertius		Tertius	30
30		Tibialis Posticus		20
20		Tibialis Anticus		10
0		Extensor Proprius Hallucis		0
55		Flexor Longus Hallucis		60
70		Flexor Brevis Hallucis		70
0	1	Extensor Longus Digitorum	1	0
0	2	Extensor Longus Digitorum	2	0
0	3	Extensor Longus Digitorum	3	0
0	4	Extensor Longus Digitorum	4	0
0	1	Extensor Brevis Digitorum	1	0
0	2	Extensor Brevis Digitorum	2	0
0	3	Extensor Brevis Digitorum	3	0
0	4	Extensor Brevis Digitorum	4	0
60	1	Flexor Longus Digitorum	1	70
55	2	Flexor Longus Digitorum	2	60
30	3	Flexor Longus Digitorum	3	60
20	4	Flexor Longus Digitorum	4	60
0	1	Flexor Brevis Digitorum	1	55
0	2	Flexor Brevis Digitorum	2	(60)
0	3	Flexor Brevis Digitorum	3	60
0	4	Flexor Brevis Digitorum	4	60
0	1	Lumbricales	1	0
0	2	Lumbricales	2	0
0	3	Lumbricales	3	0
0	4	Lumbricales	4	0
		Length		
		Calf		
		Thigh		

	Contractions and Deformities	
	Neck	
	Back	
	Hip	
	Knee	
	Ankle	
	Foot	

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CHART 21

CHILDREN'S HOSPITAL SCHOOL

PATIENT'S NAME J. N. CLINIC No. 6581

MUSCLE CHART No. 3

LEFT / RIGHT

12-4-47 HEK	9-4-47 HEK	7-25-47 HEK	5-23-47 HEK	5-8-47 HEK	4-30-47 HEK		4-30-47 HEK	5-8-47 HEK	5-23-47 HEK	7-25-47 HEK	9-4-47 HEK	12-4-47 HEK
100	80	85	60	40	30	Anterior Neck	30	40	60	85	80	100
100	100	100	100	80	80	Posterior Neck	80	80	100	100	100	100
100	70	100	100	70	70	Back	70	70	100	100	90	100
—	—	—	—	—	—	Quadratus Lumborum	—	—	—	—	—	—
						Rectus Abdominis						
						External Oblique						
						Internal Oblique						
						Lateral Abdominals						
100	100	100	70	50	50	Gluteus Maximus	60	60	70	100	100	100
90	60	80	60	45	50	Gluteus Medius	50	55	60	75	60	90
100	100	100	100	65	60	Inner Hamstrings	60	65	100	100	100	100
100	100	100	90	65	60	Outer Hamstrings	60	65	100	100	100	100
100	80	100	70	60	60	Internal Rotators	60	60	80	100	90	100
100	90	90	70	60	60	External Rotators	60	60	90	85	70	100
100	90	100	60	(50)	(50) ①	Hip Flexors ①	(50)	(50)	60	100	100	100
100	100	100	100	80	70	Sartorius	70	80	100	100	100	100
90	60	80	60	45	50	Hip Abductors	50	50	60	75	60	100
100	90	80	65	55	50	Hip Adductors	50	55	65	80	90	100
100	90	100	60	60	60	Tensor Fascia Lata	60	60	60	100	80	100
100	100	100	70	60	70	Quadriceps	70	60	70	100	100	100
100	100	100	100	100	60	Soleus	80	90	85	100	100	100
100	90	9 100	9 100	9 90	9 80	Gastrocnemius	9 80	9 90	9 100	9 100	100	100
100	100	100	100	80	70	Longus Peroneals Longus	90	100	100	100	100	100
100	100	100	100	80	70	Brevis Peroneals Brevis	90	100	100	100	100	100
100	100	100	100	80	70	Tertius Peroneals Tertius	100	100	100	100	100	100
100	100	100	100	100	80	Tibialis Posticus	90	100	90	100	100	100
100	100	100	100	100	80	Tibialis Anticus	100	100	100	100	100	100
100	90	100	70	60	80	Extensor Proprius Hallucis	70	60	70	100	90	100
100	100	100	80	70	70	Flexor Longus Hallucis	90	100	100	100	100	100
100	100	100	100	100	100	Flexor Brevis Hallucis	100	100	100	90	100	100
100	100	100	100	70	90	1 Extensor Longus Digitorum 1	90	80	100	100	100	100
/	/	/	/	/	/	2 Extensor Longus Digitorum 2	/	/	/	/	/	/
/	/	/	/	/	/	3 Extensor Longus Digitorum 3	/	/	/	/	/	/
/	/	/	/	/	/	4 Extensor Longus Digitorum 4	/	/	/	/	/	/
100	100	100	100	70	90	1 Extensor Brevis Digitorum 1	90	80	70	100	100	100
/	/	/	/	/	/	2 Extensor Brevis Digitorum 2	/	/	/	/	/	/
/	/	/	/	/	/	3 Extensor Brevis Digitorum 3	/	/	/	/	/	/
/	/	/	/	/	/	4 Extensor Brevis Digitorum 4	/	/	/	/	/	/
100	100	100	100	80	80	1 Flexor Longus Digitorum 1	100	100	100	100	100	100
/	/	/	/	/	/	2 Flexor Longus Digitorum 2	/	/	/	/	/	/
/	/	/	/	/	/	3 Flexor Longus Digitorum 3	/	/	/	/	/	/
/	/	/	/	/	/	4 Flexor Longus Digitorum 4	/	/	/	/	/	/
100	100	90	80	70	60	1 Flexor Brevis Digitorum 1	80	80	80	90	100	100
/	/	/	/	/	/	2 Flexor Brevis Digitorum 2	/	/	/	/	/	/
/	/	/	/	/	/	3 Flexor Brevis Digitorum 3	/	/	/	/	/	/
/	/	/	/	/	/	4 Flexor Brevis Digitorum 4	/	/	/	/	/	/
100	100	100	100	80	90	1 Lumbricales 1	100	100	100	100	100	100
/	/	/	/	/	/	2 Lumbricales 2	/	/	/	/	/	/
/	/	/	/	/	/	3 Lumbricales 3	/	/	/	/	/	/
/	/	/	/	/	/	4 Lumbricales 4	/	/	/	/	/	/
						Length						
						Calf						
						Thigh						

① 4-30-47 } Marked hamstring tightness 5-8-47 }	Contractions and Deformities	
	Neck	
	Back	
	Hip	
	Knee	
	Ankle	
	Feet	

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CHART 22

CHILDREN'S HOSPITAL SCHOOL

BODY MECHANICS EXAMINATION CHART

Name ______________________________ Date ______________

Diagnosis ______________________________

Onset ______________ Age ______________ Sex ______________

Occupation ______________ Height ______________ Weight ______________

Handedness ______________ Leg Length Left ______________ Right ______________

PLUMB-LINE TESTS

Test for Anterior-Posterior Alignment ______________________________

Test for Lateral Alignment: Lt. ______________ Rt. ______________

SEGMENTAL ALIGNMENT

Feet		Pronated >		Supinated		Ant. Foot Varus Pigeon Toes		Low Ant. Arch Flat Long Arch
		Int. Rot. >		Ext. Rot.		K K		
Knees		Hyperext. >		Flexed		Bow-Legs		Tibial Torsion
Pelvis		Leg Add. on Pel.		High Post. Spine		Rotation		Ant. Displace.
Low Back		Lordosis		Flat		Kyphosis		Operation
Up. Back		Kyphosis		Flat		Elevated Scap.		Abducted Scap.
Thorax		Depressed Chest		Elevated Chest		Rotation		Post. Displace.
Spine		Total Curve		Cervical		Dorsal		Lumbar
Abdomen		Protruding		Scars				
Shoulder		Low		High		Forward		Int. Rotated
Head		Forward		Torticollis				

TESTS FOR FLEXIBILITY AND CONTRACTURES

Flexibility ______________ Bk. ______ H. S. ______ G. S. ______

Extensibility ______________ Feet ______ Hip Fl. ______

Trunk Extension ______________

Trunk Lat. Flex.: To Lt. ______________ To Rt. ______________

Tensor Fas. Lata.: Lt. ______________ Rt. ______________

MUSCLE TESTS

L		R
	Mid. Trap	
	Low Trap	
	Back Exten.	
	Glut. Med.	
	Hip Ext. Rot.	
	Hamstrings	
	Hip Flexors	
	Tib. Post.	
	Toe Flexors	

R L

SHOE CORRECTION

Left		Right
	Heel	
	Sole	
	Ant. Arch	
	Long Arch	

TREATMENT

Massage to ______________

Infra-red to ______________

Diathermy to ______________

Exercises:

F. L.: Pelvic Roll ______

B. L.: Pel. Roll and Breath. ______

Pel. Roll and Leg Ex. ______

Head and Sh. Raising ______

Pectoral Stretch. ______

Hip Flex. Stretch. ______

Sd. L.: Stretch ______ tensor ______

St.: Forward Bending

T Stretch Low Bk. ______

T Stretch H. S. ______

Wall-sitting

Trapezius Exer. ______

Pectoral Stretch. ______

St.: Wall-standing ______

Other exercises ______________

Tr Changes and Dates ______________

NOTES

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CHART 23

CHILDREN'S HOSPITAL SCHOOL

BODY MECHANICS EXAMINATION CHART

Name *Mrs. A. B.* Date *4-16-48*

Diagnosis *Lumbo sacral strain*

Onset *3 years ago* Age *36* Sex *Female*

Occupation Height Weight

Handedness *Right* Leg Length: Left Right

PLUMB-LINE TESTS

Test for Anterior Posterior Alignment

Test for Lateral Alignment Lt. Rt.

SEGMENTAL ALIGNMENT

		(5/9/47)				Ant. Foot Varus		Low Ant. Arch
Feet	*Both*	Pronated *Left > Rt*		Supinated		Pigeon Toes		Flat Long Arch
	Both	Int. Rot. *>*		Ext. Rot.		K-K		
Knees		Hyperext. *>*		Flexed		Bow-Legs		Tibial Torsion
Pelvis	*Rt*	Leg Add. on Pel.		High Post. Spine		Rotation		Ant. Displace.
Low Back	*X*	Lordosis		Flat		Kyphosis		Operation
Up. Back	*X*	Kyphosis		Flat		Elevated Scap.		Abducted Scap.
Thorax		Depressed Chest		Elevated Chest		Rotation		Post. Displace.
Spine		Total Curve		Cervical		Dorsal		Lumbar
Abdomen		Protruding		Scars				
Shoulder	*Rt*	Low		High		Forward		Int. Rotated
Head	*X*	Forward		Torticollis				

TESTS FOR FLEXIBILITY AND CONTRACTURES

(1) Flexibility *Limited 8" from toes* Rt. *X* H. S. G. S.

Extensibility *Limited* Pect. *Both* Hip Fl.

Trunk Extension

Trunk Lat. Flex.: To Lt. *Limited* To Rt. *Normal*

Tensor Fas. Lata.: Lt. Rt.

MUSCLE TESTS

L		R
60%	Mid. Trap.	*60%*
60%	Low Trap.	*60%*
100%	Back Extens.	*100%*
100%	Glut. Med.	*60%*
	Hip Ext. Rot.	
	Hamstrings	
	Hip Flexors	
	Tib. Post.	
	Toe Flexors	

SHOE CORRECTION

Left		Right
1/8 straight raise		
	Heel	
	Sole	
	Ant. Arch	
	Long. Arch	

TREATMENT

Massage to *low back*

Infra-red to *low back*

Diathermy to

Exercises:

F. L.:	Pelvic Roll	*X*
B. L.:	Pel. Roll and Breath.	*X*
	Pel. Roll and Leg Sl.	*X*
	Head and Sh. Raising	*X*
	Pectoral Stretch.	*X*
	Hip Flex. Stretch.	
Sd. L.:	Stretch. tensor	
Sit.:	Forward Bending	
	T Stretch Low Bk.	*X* (1)
	T Stretch H. S.	
	Wall-sitting	
	Trapezius Exer.	*X*
	Pectoral Stretch.	*X*
St.:	Wall-standing	*X*

Other exercises

T Changes and Dates

NOTES: *[(1) The 8" limitation in the forward bending flexibility test is not normal for an adult]*

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CHART 24

CHAPTER III

UPPER EXTREMITY AND SCAPULAR MUSCLES

Fig 7 Flexor Pollicis Longus

Patient

Sitting or supine

Fixation

The examiner stabilizes the wrist and proximal joint of the thumb in neutral position (Holding the wrist in flexion makes it difficult for the patient actively to flex the distal phalanx through full range of motion)

Test

Flexion of the distal phalanx of the thumb

Pressure

Against the palmar surface of the distal phalanx, in the direction of extension

Weakness

Allows a hyper-extension of the distal phalanx

Lessens the ability to flex the distal phalanx, and interferes with holding a pencil for writing and with picking up small objects between the thumb and fingers

Contracture

Flexion deformity of the distal phalanx

Fig 8 Flexor Pollicis Brevis

PATIENT

Sitting or supine

FIXATION

The examiner stabilizes the wrist in neutral position

TEST

Flexion of the proximal phalanx of the thumb without flexion of the distal phalanx

PRESSURE

Against the palmar surface of the proximal phalanx in the direction of extension.

WEAKNESS

Allows hyper-extension of the proximal phalanx

Results in the inability to grip objects firmly between the thumb and fingers

CONTRACTURE

Flexion deformity of the proximal phalanx

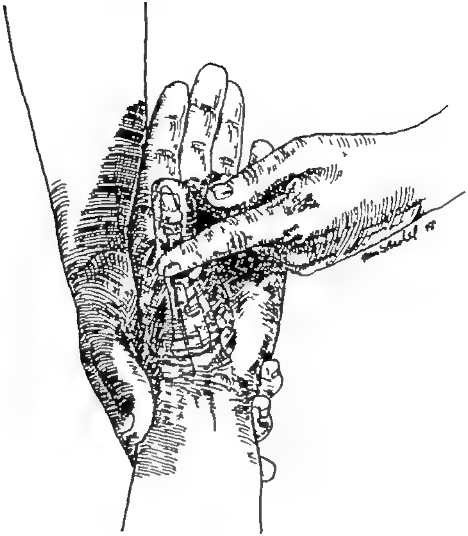


FIG 9 Abductor Pollicis Brevis line drawing

ORIGIN

The tuberosity of the navicular the ridge of the greater multangular and the transverse carpal ligament

INSERTION

The base of the first phalanx of the thumb radial side

ACTION

Abduction of the thumb from the second metacarpal toward the midline of the ventral surface of the wrist

FIG 10 Abductor Pollicis Brevis

PATIENT

Sitting or supine

FIXATION

The examiner stabilizes the wrist in neutral position

TEST

Abduction of the thumb from the base of the index finger toward the midline of the ventral surface of the wrist

PRESSURE

Against the proximal phalanx in the direction of adduction lateral to the index finger (directly opposite the line of pull of the muscle fibers as seen in the next figure)

WEAKNESS

Interferes with the ability to abduct the thumb sufficiently to grasp a large object

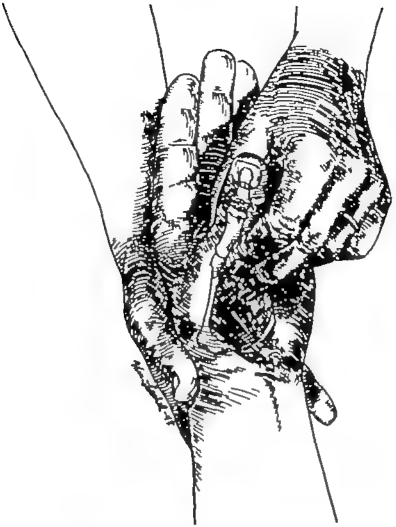


FIG 11 Opponens Pollicis, line drawing

ORIGIN

The transverse carpal ligament and the ridge of the greater multangular

INSERTION

Along the entire length of the first metacarpal bone radial side

ACTION

Abducts the thumb from the index finger toward the ventral surface of the wrist adducts the thumb toward the midline of the hand (in this abducted position) and rotates the metacarpal bone so that the thumb-nail shows in palmar view. The abductor pollicis brevis and the opponens pollicis act like cables lifting the thumb up and carrying it horizontally toward the midline of the hand in a crane-like action. The opponens pollicis test has frequently been described as the ability to touch the thumb to the little finger. This test is in reality a combination of opponens pollicis flexor pollicis brevis and adductor pollicis and if the resistance is applied against the proximal phalanx of the thumb in opposition to the line of pull toward the little finger the flexor pollicis brevis and the adductor pollicis are being tested rather than the opponens

Fig 12 Opponens Pollicis

Patient

Sitting or supine.

Fixation

The examiner stabilises the wrist in neutral position

Test

Abduction of the thumb from the index finger toward the midline of the ventral surface of the wrist with rotation of the metacarpal bone so that the thumb-nail shows in palmar view

Pressure

Against the metacarpal bone in the direction of derotation and adduction toward the index finger (directly opposite the line of pull of the muscle fibers as seen in figure 11)

Weakness

Allows the first metacarpal to drop into a position of extension and outward rotation (The phalanges may flex due to the tension of the thumb flexors) There is a flattening of the thenar eminence The patient encounters difficulty in holding a pencil for writing and is unable to grasp objects firmly between the thumb and fingers

Note

The palmaris longus tenses during the opponens pollicis test With part of the origin of the opponens pollicis in the transverse carpal ligament and part of the insertion of the palmaris longus into the transverse carpal ligament it may be easily understood why the palmaris longus contracts during the opponens test

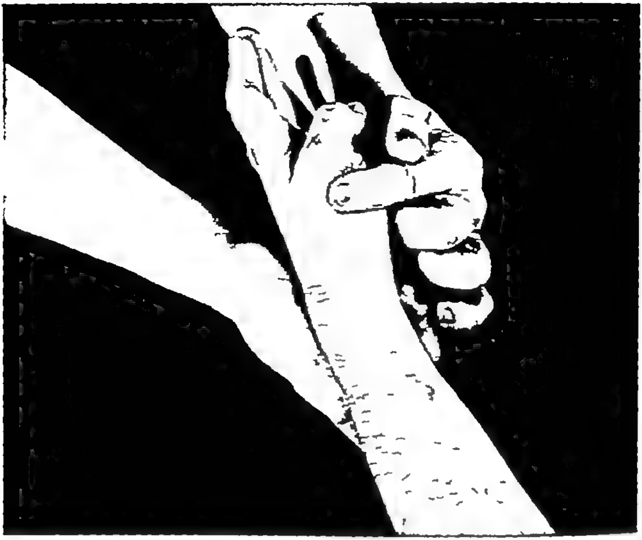


Fig 13 Abductor Pollicis Longus

Patient

Sitting or supine

Fixation

The examiner supports the wrist in a neutral position

Test

Abduction of the first metacarpal bone toward the radial side

Pressure

Against the lateral surface of the distal end of the first metacarpal, in the direction of adduction toward the midline of the hand.

Weakness

Allows the metacarpal bone of the thumb to drop into adduction toward the palm of the hand and permits an ulnar deviation of the hand

Contracture

Abducted position of the first metacarpal with slight radial deviation of the hand

Fig 14 Extensor Pollicis Brevis

PATIENT

Sitting or supine

FIXATION

The examiner supports the wrist in a neutral position

TEST

Extension of the proximal phalanx of the thumb

PRESSURE

Against the dorsal surface of the proximal phalanx, in the direction of flexion

WEAKNESS

Allows a flexion position of the proximal phalanx of the thumb

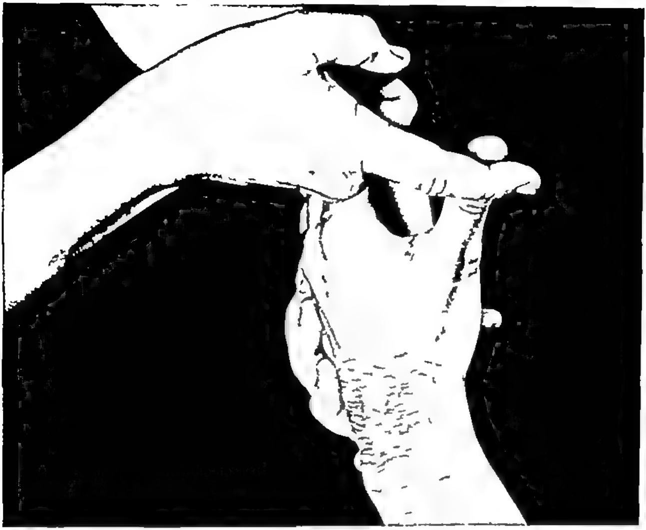


Fig 15 Extensor Pollicis Longus

Patient

Sitting or supine

Fixation

The examiner supports the wrist and proximal phalanx of the thumb in neutral position (Holding the wrist in hyper-extension during this test makes it difficult for the patient to hold against maximum pressure even though strength of the extensor pollicis longus is normal.)

Test

Extension of the distal phalanx of the thumb

Pressure

Against the dorsal surface of the distal phalanx of the thumb in the direction of flexion

Weakness

Allows the distal phalanx of the thumb to assume a flexed position.

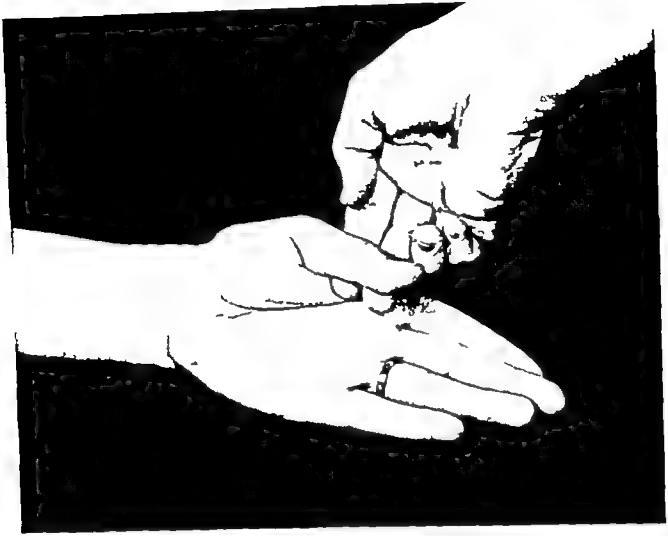


FIG 16 Adductor Pollicis

PATIENT

Sitting or supine.

FIXATION

The patient's hand may be supported on the table (as shown) or may be stabilized by the examiner

TEST

Adduction of the thumb toward the base of the index and middle fingers palmar surface

PRESSURE

Against the medial surface of the thumb in the direction of abduction toward the ventral surface of the wrist radial side

WEAKNESS

Results in the inability to clench the thumb firmly over the closed fingers

CONTRACTURE

Adduction of the thumb toward the palm of the hand

NOTE

A test that is frequently used for strength of the adductor pollicis is the ability to hold a piece of paper between the thumb and second metacarpal An individual with a well developed thumb adductor group may have difficulty in this test The bulk of the muscle itself prevents close approximation of the thumb to the second metacarpal

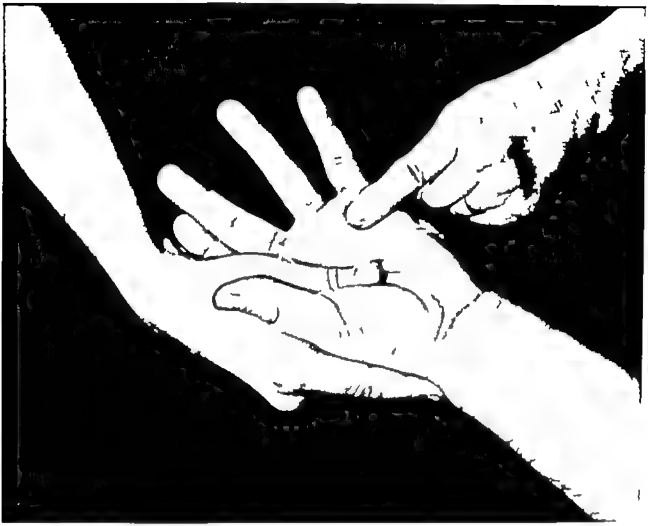


Fig 17 Opponens Minimi Digiti

Patient

Sitting or supine

Fixation

The wrist is supported in neutral position by the examiner or may rest on the table for support The first metacarpal is held firm by the examiner

Test

Opposition of the fifth metacarpal toward the first metacarpal This muscle pulls and slightly rotates the fifth metacarpal in such a way as to help cup the palm of the hand

Pressure

Against the palmar surface along the fifth metacarpal in a downward-outward direction flattening the palm of the hand (One finger pressure was used in order to make the muscle belly visible in the picture)

Weakness

Allows a flattening of the palm of the hand and makes it difficult if not impossible to oppose the little finger toward the thumb

FIG 18 Opposition of the little finger

The movement of touching the tip of the little finger to the thumb is accomplished by a combination of actions of the little finger flexors and the opponens minimi digiti The fourth lumbrical abductor minimi digiti (and flexor minimi digiti) flex the metacarpo-phalangeal joint and the opponens minimi digiti pulls and rotates the fifth metacarpal in performing the movement of opposition

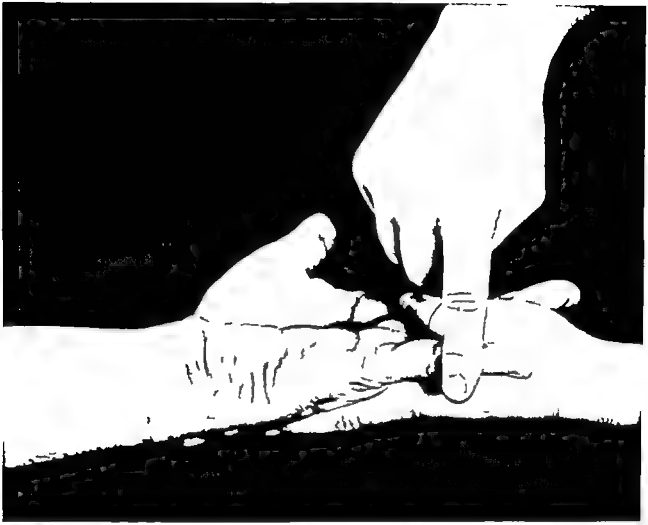


Fig 19 Abductor Minimi Digiti, ulnar view

Patient

Sitting or supine.

Fixation

The hand may be supported with the wrist in neutral position by the examiner or may rest on the table for support.

Test

Abduction of the fifth digit toward the ulnar side

Pressure

Against the ulnar side of the first second or third* phalanx of the little finger in the direction of adduction toward the midline of the hand

Weakness

Allows the little finger to remain in adduction toward the midline of the hand.

*** Note**

One should be consistent in the placing of pressure in all finger abduction and adduction tests Pressure against the sides of the middle phalanges seems least awkward for all the tests.

Fig 20 Abductor Minimi Digiti palmar view

This figure illustrates that the abductor minimi digiti acts as if it were a fifth dorsal interosseus

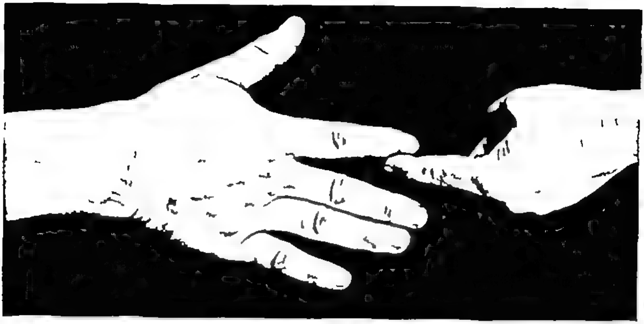


FIG 21 *First Palmar Interosseus*

PATIENT

Sitting or supine

FIXATION

The hand may be supported in a neutral position by the examiner or may rest on the table for support Though it is not illustrated the middle finger should be stabilized during this test

TEST

Adduction of the index finger toward the midline of the hand

PRESSURE

Against the ulnar side of the distal phalanx *of the index finger in the direction of abduction* toward the radial side

Palmar interossei are three in number *Tests for the second* and third are as *follows*

SECOND

Adduction of the ring finger toward the midline of the hand (Stabilize middle finger)

THIRD

Adduction of the little finger toward the midline of the hand. (Stabilize ring finger)

WEAKNESS

Lessens the ability to adduct the index ring and little fingers.

Lessens the strength of flexion of metacarpo-phalangeal joints and extension of interphalangeal joints

The following discussion in regard to shortness and contracture of interossei with the differentiation between the dorsal and palmar is the opinion of the authors based on functional analysis of the muscle actions. The dorsal interossei are generally credited with assisting the lumbricales and palmar interossei in the actions of flexion of the metacarpo-phalangeal joints and extension of the interphalangeal joints The authors feel that the palmar interossei and lumbricales do act together in this *motion but that the dorsal* interossei normally assist the extensor communis in extension of all joints

The fact that fingers tend to abduct as they are strongly extended and adduct as the metacarpo-phalangeal joints are flexed lends support to this theory. While there is a tendency for the fingers to adduct due to the mechanics of the joint action in flexion this is not necessarily true of the abduction-extension action. The fingers can be passively adducted in the extended position but resist passive abduction in the position of metacarpo-phalangeal flexion with interphalangeal joint extension.

The bony origin and the position of the tendons of the dorsal interossei suggest their reinforcement of finger extension at the metacarpo-phalangeal joints. The position of the palmar is in line with the function attributed to the palmar group.

Tests of the dorsal and palmar interossei in their abduction and adduction action should be made in order to differentiate between the strength of the two along with any tests for tightness. This is true because contracture (unless of an ischemic nature) seldom accompanies weakness.

PALMAR

Contracture

Same as the position of lumbricales contracture namely flexion of the metacarpo-phalangeal joints with extension of the interphalangeal joints with the added feature of more pronounced finger adduction.

Shortness

Inability to flex (either passively or actively) the interphalangeal joints if the metacarpo-phalangeal joint is hyperextended or the inability to extend the metacarpo-phalangeal joint if the interphalangeal joints are flexed.

DORSAL

Contracture

Extension of fingers at all joints.

Shortness

Inability to flex the interphalangeal joints if the metacarpo-phalangeal joint is flexed or the inability to flex the metacarpophalangeal joint if the interphalangeal joints are flexed.

It is probable that in a hand which has been held for some time in a position of contracture of the lumbricales and palmar interossei that the dorsal aponeurosis at the metacarpo-phalangeal joint becomes weakened and stretched to such an extent that the dorsal interossei drop into a position to function along with the lumbricales and palmar interossei in flexion of the metacarpo-phalangeal joints.

Fig 22 First Dorsal Interosseus

Patient

Sitting or supine

Fixation

The hand may be supported in a neutral position by the examiner or may rest on the table for support Though it is not shown in the illustration the thumb should be stabilized in radial abduction during the test of the first dorsal interosseus

Test

Abduction of the index finger toward the radial side

Pressure

Against the radial side of the middle phalanx of the index finger in the direction of adduction toward the midline of the hand

The dorsal interossei are four in number with one on either side of the middle finger Tests for the second third and fourth are as follows

Second

Abduction of the middle finger toward the radial side (Stabilize index finger)

Third

Abduction of the middle finger toward the ulnar side (Stabilize ring finger)

Fourth

Abduction of the ring finger toward the ulnar side (Stabilize little finger)

Weakness

Lessens the ability to abduct the index, middle and ring fingers

Lessens extension strength of interphalangeal (and metacarpo-phalangeal) joints

Contracture & Shortness

(See discussion under Palmar Interossei.)

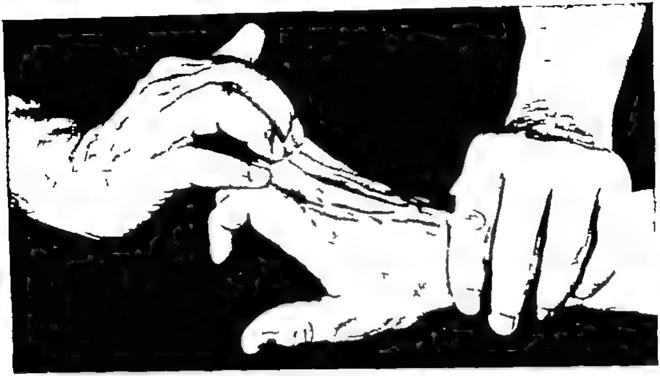


FIG 23 Extensor Digitorum Communis

PATIENT

Sitting or supine

FIXATION

The examiner stabilizes the wrist in neutral position. This is necessary because flexion of the wrist will passively extend the metacarpo-phalangeal joints.

TEST

Extension of the metacarpo-phalangeal joints of the fingers with interphalangeal joints relaxed

PRESSURE

Against the dorsal surface of the proximal phalanges in the direction of flexion.

NOTE

The extensor digitorum communis extends the metacarpo-phalangeal joints without assistance from the lumbricales which do assist in interphalangeal joint extension. By limiting the test of the extensor digitorum communis to extension of the metacarpo-phalangeal joints rather than permitting extension of all finger joints the extensor communis action is differentiated from that of the lumbricales and (palmar) interossei. The extensor minimi digiti and extensor indicis assist the extensor communis in extension of the little finger and the index finger. If either or both of these fingers extend without extension of the middle and ring fingers during the communis test the action may be considered as that of the extensor indicis or minimi digiti

WEAKNESS

Decreases the ability to extend the metacarpo-phalangeal joints of the fingers resulting in a position of flexion of these joints. Extension power of the wrist is diminished

CONTRACTURE

Hyperextension deformity of the metacarpo-phalangeal joints

SHORTNESS

Hyperextension of the metacarpo-phalangeal joints if the wrist is flexed, or extension of the wrist if the metacarpo-phalangeal joints are flexed

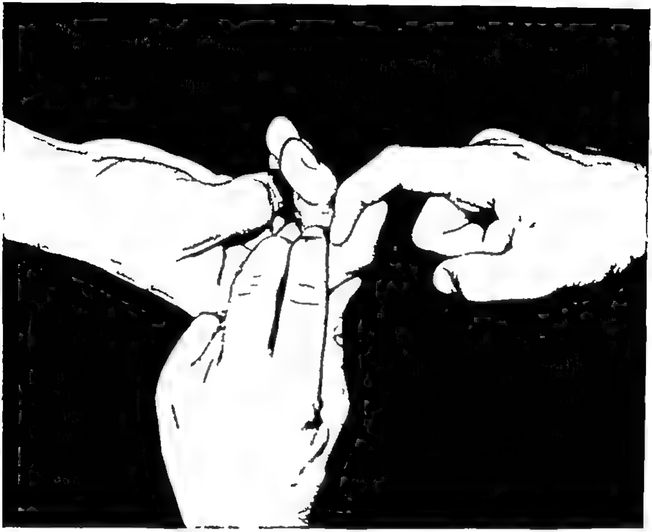


Fig 24 Flexor Digitorum Profundus

Patient

Sitting or supine

Fixation

The examiner stabilizes the proximal inter phalangeal joint and metacarpo-phalangeal joint The wrist should be in neutral position or in slight extension

Test

Flexion of the distal phalanx of the second third fourth and fifth digits (Each finger is tested as illustrated above for the first finger)

Pressure

Against the palmar surface of the distal phalanx in the direction of extension

Weakness

The strength to flex the distal joints of the fingers is diminished in direct proportion to the weakness of this muscle The strength of wrist flexion is decreased

Contracture

Flexion deformity of the distal phalanges of the fingers

Shortness

Flexion of the distal phalanges of the fingers if the wrist is extended or flexion of the wrist if the fingers are extended

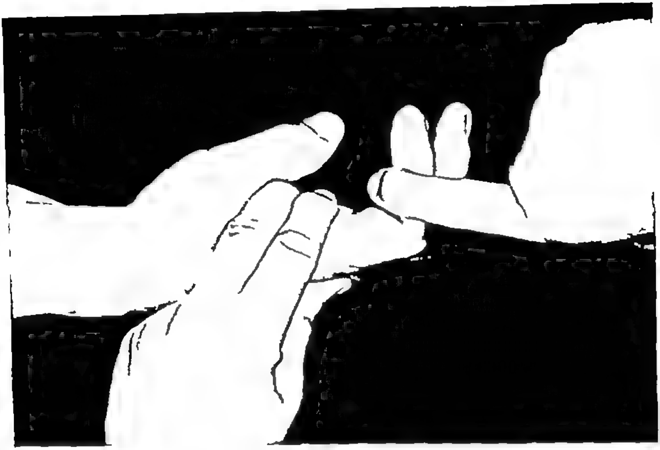


FIG 25 Flexor Digitorum Sublimis

PATIENT

Sitting or supine

FIXATION

The examiner stabilizes the metacarpophalangeal joint with the wrist in neutral position or in slight extension.

TEST

Flexion of the middle phalanx with the distal phalanx extended of the second third fourth and fifth* digits (Each finger is tested as illustrated for the first finger)

PRESSURE

Against the palmar surface of the middle phalanx in the direction of extension.

WEAKNESS

Lessens the strength of the grip and wrist flexion

Interferes with finger function in such activities as typing piano playing and playing some stringed instruments in which the proximal interphalangeal joint is flexed while the distal joint is extended

Weakness causes loss of joint stability at the proximal interphalangeal joint of the fingers so that in the movement of finger extension this joint hyperextends

CONTRACTURE

Flexion deformity of the middle phalanx of the fingers

SHORTNESS

Flexion of the middle phalanges of the fingers if the wrist is extended or flexion of the wrist if the fingers are extended.

* NOTE

It appears to be the exception rather than the rule to obtain isolated sublimis action in the fifth digit

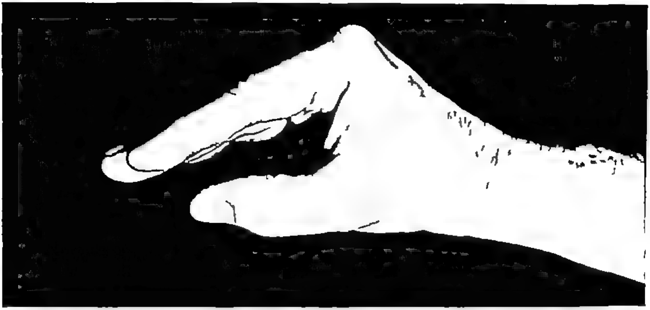


FIG 26 Lumbricales

PATIENT

Sitting or supine

FIXATION

The examiner stabilizes the wrist in slight extension (The fixation and pressure have been omitted in the illustration to make the position clear)

TEST

Flexion of the metacarpo-phalangeal joints with simultaneous extension of the interphalangeal joints

PRESSURE

(1) Against the palmar surface of the proximal phalanges in the direction of extension and (2) against the dorsal surface of the distal and middle phalanges in the direction of flexion.

WEAKNESS

Allows the claw hand position of the fingers i e., hyperextension of the metacarpo-phalangeal joints with flexion of the interphalangeal joints (See fig 3)

CONTRACTURE

Flexion deformity of the metacarpo-phalangeal joints with extension of the interphalangeal joints

SHORTNESS

Inability to flex (actively or passively) the interphalangeal joints if the metacarpo-phalangeal joints are hyperextended or the inability to extend the metacarpo-phalangeal joints if the interphalangeal joints are flexed. The wrist should be allowed to flex slightly in order to differentiate tightness of lumbricales from any flexor sublimis or profundus tightness that may exist.

NOTE

The lumbricales are assisted by the palmar interossei. The dorsal interossei are generally credited with assisting in this function, but in the opinion of the authors this is questionable (See discussion under Palmar Interossei p 71)

Fig 27 Function of the Lumbricales

An important function of the lumbricales is demonstrated in this illustration With paralysis or weakness of the lumbricales an individual encounters great difficulty in holding a book or a newspaper in one hand

Fig 28 Flexor Carpi Radialis

PATIENT

Sitting or supine

FIXATION

The forearm lies in supination and may rest on the table for support or may be supported by the examiner

TEST

Flexion of the wrist toward the radial side

PRESSURE

Against the thenar eminence in the direction of ulnar extension

WEAKNESS

Allows a deviation of the hand toward ulnar extension

Flexion power of the wrist is diminished and the strength of the forearm pronation may be slightly diminished

CONTRACTURE

Wrist flexion toward the radial side with slight pronation of the forearm.

NOTE

The palmaris longus action cannot be ruled out in this test

(See also note under Flexor Carpi Ulnaris)

Fig 20 Flexor Carpi Ulnaris

PATIENT

Sitting or supine

FIXATION

The forearm lies in supination and may rest on the table for support or may be supported by the examiner

TEST

Flexion of the wrist toward the ulnar side

PRESSURE

Against the hypo-thenar eminence in the direction of radial extension

WEAKNESS

Allows a deviation of the hand toward radial extension

Flexion power of the wrist is diminished.

CONTRACTURE

Wrist flexion with ulnar deviation

NOTE

Fingers will normally be in a position of passive extension when the wrist is flexed If the fingers actively flex as the wrist flexion is attempted the patient shows evidence of substituting the finger flexors for wrist flexors

Fig 28 Flexor Carpi Radialis

Patient

Sitting or supine

Fixation

The forearm lies in supination and may rest on the table for support or may be supported by the examiner

Test

Flexion of the wrist toward the radial side

Pressure

Against the thenar eminence in the direction of ulnar extension

Weakness

Allows a deviation of the hand toward ulnar extension

Flexion power of the wrist is diminished and the strength of the forearm pronation may be slightly diminished

Contracture

Wrist flexion toward the radial side with slight pronation of the forearm

Note

The palmaris longus action cannot be ruled out in this test

(See also note under Flexor Carpi Ulnaris.)

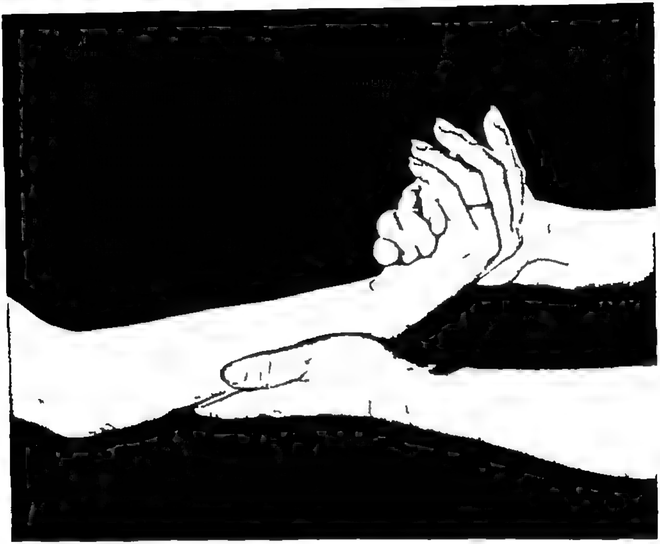


Fig 20 Flexor Carpi Ulnaris

PATIENT

Sitting or supine

FIXATION

The forearm lies in supination and may rest on the table for support or may be supported by the examiner

TEST

Flexion of the wrist toward the ulnar side

PRESSURE

Against the hypo-thenar eminence in the direction of radial extension

WEAKNESS

Allows a deviation of the hand toward radial extension

Flexion power of the wrist is diminished

CONTRACTURE

Wrist flexion with ulnar deviation

NOTE

Fingers will normally be in a position of passive extension when the wrist is flexed If the fingers actively flex as the wrist flexion is attempted, the patient shows evidence of substituting the finger flexors for wrist flexors

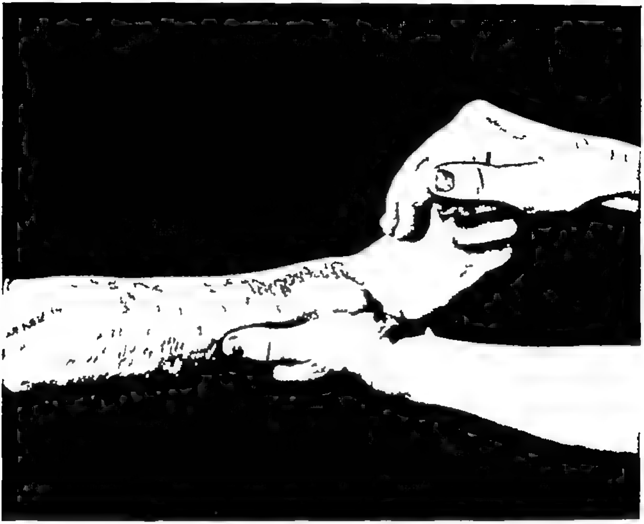


FIG 30 Extensor Carpi Radialis Longus and Brevis

PATIENT

Sitting or supine

FIXATION

The forearm lies in pronation and may rest on the table for support or may be stabilized by the examiner

TEST

Extension of the wrist toward the radial side

PRESSURE

Against the dorsum of the hand along the second metacarpal bone in the direction of ulnar flexion.

WEAKNESS

Allows a deviation of the hand toward ulnar flexion

Extension power of the wrist is diminished.

CONTRACTURE

Wrist extension with radial deviation

NOTE

(See under Extensor Carpi Ulnaris.)

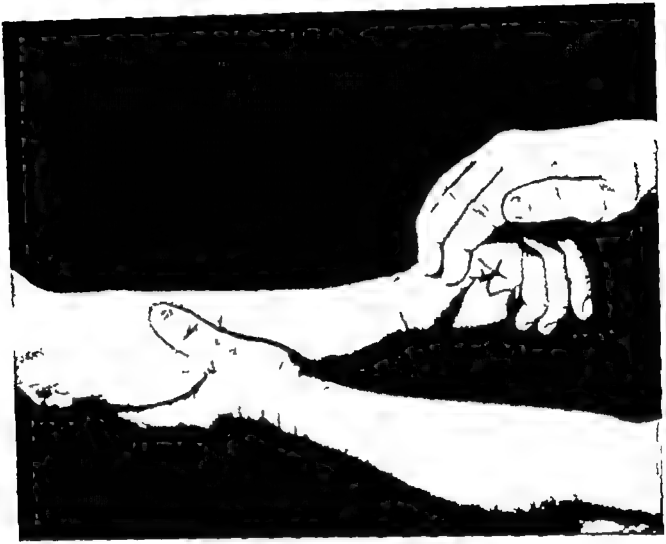


FIG 31 Extensor Carpi Ulnaris

PATIENT

Sitting or supine

FIXATION

The forearm lies in pronation and may rest on the table for support or may be stabilized by the examiner

TEST

Extension of the wrist toward the ulnar side

PRESSURE

Against the dorsum of the hand along the fifth metacarpal bone in the direction of radial flexion

WEAKNESS

Allows a deviation in the direction of radial flexion and diminishes the strength of wrist extension

CONTRACTURE

Ulnar deviation of the hand with slight extension

NOTE

Fingers will normally be in a position of passive flexion when the wrist is extended If the fingers actively extend as the wrist extension is attempted the patient shows evidence of substituting the extensor digitorum communis for the action of the wrist extensors.

(a) (b)

FIG 32 Palmaris Longus

PATIENT

Sitting or supine

FIXATION

The forearm may rest on the table for support in a position of supination

TEST

Flexion of the wrist and tensing of the palmar fascia by strongly cupping the palm of the hand

PRESSURE

If pressure is applied as illustrated in fig (b) it may be applied against the thenar and hypothenar eminences in the direction of flattening the palm of the hand and extending the wrist In practice pressure is not used and the muscle is not graded except as zero weak or apparently normal

WEAKNESS

Lessens the ability to cup the palm of the hand. Flexion power of the wrist is diminished

CONTRACTURE

Draws the palm into a cupped position, and by exerting a pull on the transverse carpal ligament tends to approximate the first and fifth metacarpals

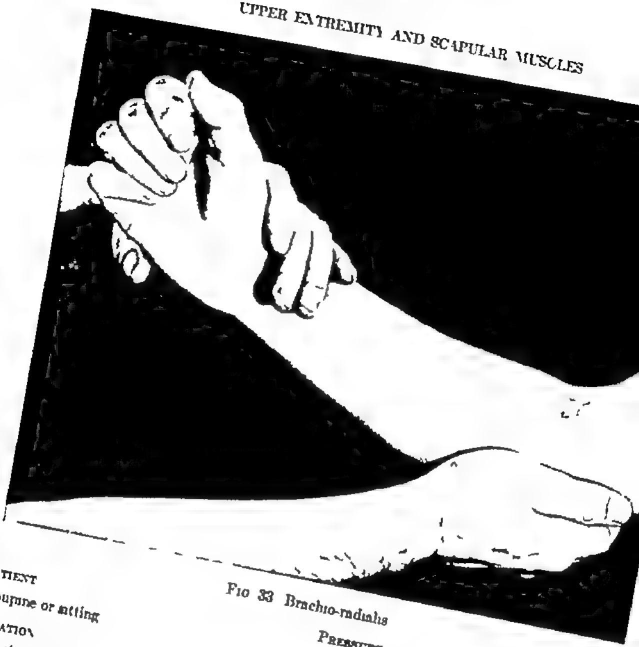


Fig 33 Brachio-radialis

PATIENT

Supine or sitting

FIXATION

If the elbow rests on a table the examiner places one hand under the elbow to cushion it from the pressure of the table If the elbow or the upper arm is not supported by the table the examiner stabilizes the upper arm.

TEST

Flexion of the elbow with the forearm neutral between pronation and supination The belly of the brachio-radialis muscle must be seen and felt during this test because the movement can be produced by other muscles

PRESSURE

Against the lower forearm in the direction of elbow extension

WEAKNESS

From a position of full supination this muscle pronates to midline and from a position of full pronation it supinates to midline It acts in elbow flexion whether the forearm is supinated or pronated. The result is that weakness of this muscle tends to diminish the strength of elbow flexion and both supination and pronation to midline

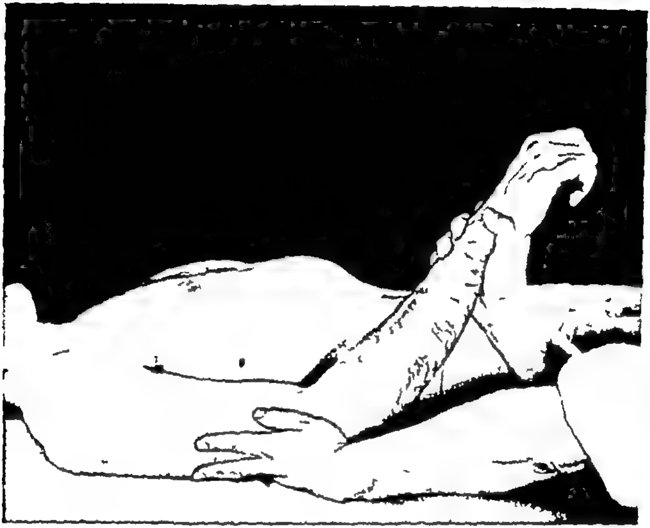


Fig 34 Pronator Quadratus and Teres

PATIENT

Supine or sitting

FIXATION

The elbow should be held against the patient's side or be stabilized by the examiner to avoid shoulder movement

TEST

Pronation of the forearm with the elbow in moderate extension.

PRESSURE

The examiner's hand is placed at the lower forearm above the wrist (to avoid twisting the wrist) and pressure is applied in the direction of supinating the forearm.

WEAKNESS

Allows a supinated position of the forearm. Interferes with many every-day functions of the arm for example, turning a doorknob using a knife to cut meats or turning the hand downward in picking up a cup or other object

CONTRACTURE

With the forearm in a position of pronation contracture, there is marked interference with many normal functions of the hand and arm.

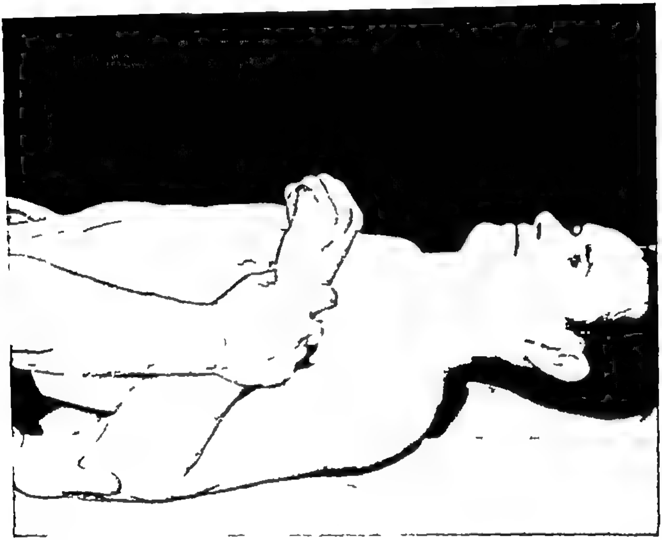


Fig 35 Pronator Quadratus

Patient

Supine or sitting

Fixation

The elbow should be held against the patient's side or be stabilized by the examiner to avoid shoulder movement

Test

Forearm pronation with the elbow completely flexed.

Pressure

The examiner's hand is placed at the lower forearm above the wrist (to avoid twisting the wrist) and pressure is applied in the direction of supinating the forearm

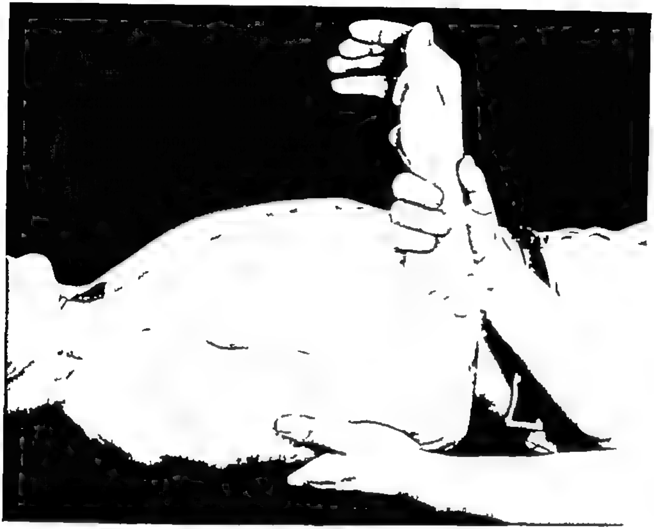


FIG 36 Supinators Biceps and Supinator Brevis

PATIENT

Supine

FIXATION

The elbow should be held against the patient s side or be stabilized by the examiner to avoid shoulder movement

TEST

Complete supination of the forearm with the elbow at right angles

PRESSURE

The examiner's hand is placed at the lower forearm above the wrist (to avoid twisting the wrist) and pressure is applied in the direction of pronating the forearm

WEAKNESS

Allows the forearm to remain in a pronated position Interferes with many functions of the extremity particularly in the motions involved in feeding oneself

CONTRACTURE

Position of elbow flexion with forearm supination. Causes a marked interference with functions of the extremity that involve the change from supinated to pronated position of the forearm.

Fig 37 Supinator Brevis (tested with biceps on a stretch)

Patient

Sitting or standing.

Fixation

The examiner holds the shoulder elbow and wrist in extension

Test

Supination of the forearm

Pressure

At the lower end of the forearm above the wrist in the direction of pronation

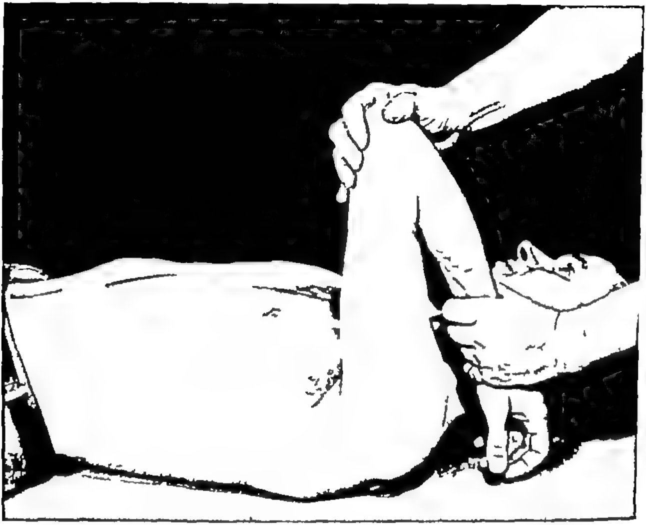


Fig 38 Supinator Brevis (tested with biceps in a position of maximum relaxation)

Patient

Supine

Fixation

The examiner holds the shoulder in flexion, with the elbow completely flexed

Test

Supination of the forearm

Pressure

At the lower end of the forearm above the wrist in the direction of pronating the forearm.

Fig 39 Triceps and Anconeus (alternate test)

Patient

Supine

Fixation

The upper arm is supported in a position perpendicular to the table

Test

Extension of the elbow

Pressure

Against the forearm in the direction of elbow flexion.

Fig 40 Triceps and Anconeus

Patient

Prone

Fixation

The arm is at shoulder level with the upper arm supported on the table and the forearm hanging over the side of the table One hand of the examiner may be placed under the upper arm near the elbow to avoid table pressure as the examiner applies pressure in the test

Test

Extension of the elbow

Pressure

Against the forearm, in the direction of elbow flexion.

Weakness

Results in the inability to extend the forearm against gravity. There is interference with every-day functions which involve elbow extension in reaching upward, such as turning on an overhead light or reaching toward a high shelf. There is loss of ability to throw objects or push with the extended elbow. If an individual walks with the aid of crutches or a cane, his handicap is increased by the lack of triceps.

Contracture

Extension deformity of the elbow. Marked interference with the every-day functions that involve elbow flexion.

Note

The triceps and anconeus act together in the extension of the elbow, but the long head of the triceps has an additional action because it crosses the shoulder joint. From a neurological or orthopedic standpoint, it may be necessary to differentiate between the action of the triceps and the anconeus in elbow extension. In a lesion at the level of the middle or lower third of the humerus, the anconeus branch (which is a long branch from the mid humeral region to the anconeus muscle) may be involved while the triceps may be unaffected. The belly of the anconeus muscle is below the elbow joint with the tendon crossing over to the lateral epicondyle of the humerus, making it possible to distinguish it from the triceps. Loss of anconeus power materially reduces the strength of elbow extension. On early examination of a nerve lesion, one may find upon careful analysis that an 80% elbow extension strength is actually the result of normal triceps and zero anconeus.

Fig 41 Elbow flexors with forearm supinated

Patient

Supine or sitting

Fixation

Elbow is supported by the examiner to keep table pressure off the posterior elbow joint

Test

Elbow flexion to right angle with forearm in supination

Pressure

Against the lower forearm in the direction of extension

Weakness

Results in the inability to flex the forearm against gravity There is marked interference with many every-day functions such as feeding oneself or combing the hair

Contracture

Flexion deformity of the elbow

Note

If the biceps and brachialis anticus are very weak, the patient will pronate the forearm before he flexes the elbow substituting with brachio-radialis, pronator teres and wrist flexors.

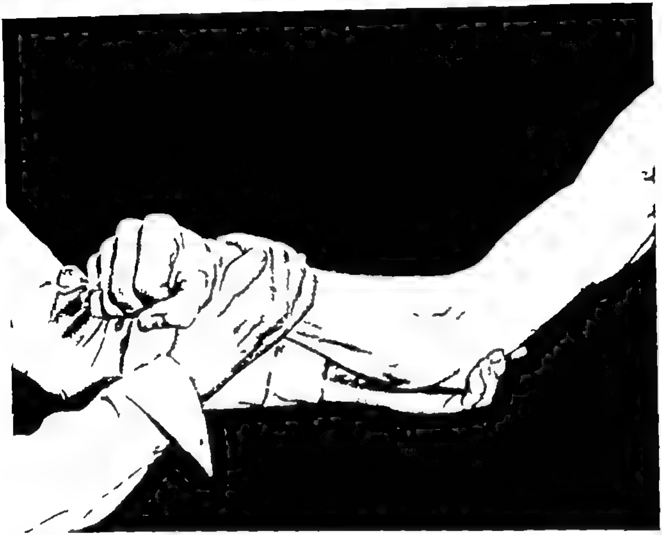


FIG 42 Elbow flexors with forearm pronated

This figure illustrates that the biceps act in flexion even though the forearm is in pronation. Since the brachialis anticus is inserted on the ulna the position of the forearm whether in supination or pronation does not affect the action of this muscle in elbow flexion. The brachio-radialis appears to have a slightly stronger action in the pronated position of the forearm in the elbow flexion test than in the supinated position although its strongest action in flexion is with the forearm in mid position

Fig 43 Anterior Deltoid (sitting)

Patient

Sitting

Fixation

If the fixation muscles of the scapula are weak, the examiner must stabilize the scapula The examiner should apply counter pressure against the posterior shoulder girdle to insure stability as pressure is applied

Test

Shoulder abduction in the slightly forward plane with the humerus in slight external rotation. (Elbow is flexed to denote the degree of shoulder rotation)

The rotation position of the arm in the anterior deltoid test varies with the position of the body In the supine position, the best

action of the muscle is obtained by internal rotation position of the shoulder bringing about the anatomical action of abduction and internal rotation. In the sitting position it is necessary to externally rotate the shoulder slightly in order to bring out the maximum action of the anterior deltoid in its anti-gravity function.

PRESSURE

Against the upper surface of the arm in a downward-slightly backward direction.

In the tests for the deltoid (anterior, middle and posterior) the examiner's hand that is applying pressure is held straight to denote photographically the direction of pressure which is perpendicular to the palmar surface of the examiner's hand.

Fig 44 Anterior Deltoid (supine)

Patient

Supine

Fixation

The trapezius and serratus anterior should stabilize the scapula in all the deltoid tests and if these muscles are weak the examiner should stabilize the scapula

Test

Shoulder abduction in the position of slight flexion and internal rotation with the patient's hand resting on his chest. One hand of the examiner is placed under the patient's wrist to make sure that he does not lift the elbow by reverse action of the wrist extensors which may occur if the patient is allowed to press the hand down on the chest

Pressure

Against the upper surface of the arm just above the elbow in the direction of adduction toward the side of the body

Fig 45 Middle Deltoid and Supraspinatus

Patient

Sitting

Fixation

The examiner must stabilize the scapula if the fixation muscles of the scapula are weak. The position of the trunk in relation to the arm in this test is such that a stable trunk will need no further stabilization by the examiner

Test

Shoulder abduction in the side line position without rotation (Elbow is flexed to denote the neutral position of the arm in relation to rotation)

Pressure

Against the upper surface of the arm above the elbow directly downward in the direction of adduction toward the side of the body

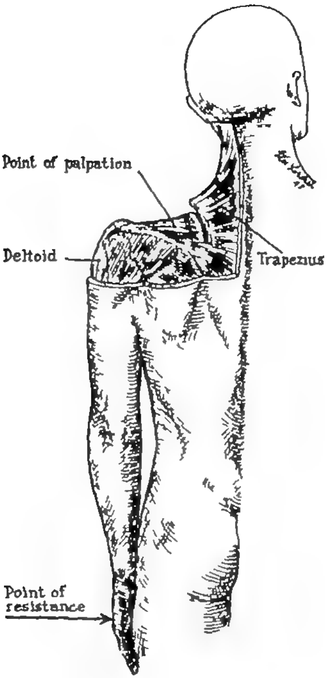


FIG 46 Supraspinatus

PATIENT

Sitting or standing.

FIXATION

None necessary since maximum resistance is not required

TEST

Have the patient attempt to abduct the humerus as resistance is applied, and palpate the supraspinatus muscle (This test requires a resisting pressure rather than pressure against a held position)

No effort is made to distinguish the supraspinatus from the deltoid in the strength test for the purpose of grading but this muscle can be palpated to determine whether or not it is active

Some authorities have indicated that the supraspinatus is probably responsible for the first few degrees of abduction of the humerus Both the deltoid and the supraspinatus are one-joint muscles with essentially the same direction of pull The supraspinatus has a slight advantage in leverage but is so much smaller than the deltoid that its action in beginning abduction is probably no greater than the deltoid

The description and illustration here indicate that the beginning abduction motion is advisable in testing for the supraspinatus but not for reason of its isolated action The supraspinatus must be palpated through the trapezius (upper and middle fibers) since it is completely covered by this muscle After a few degrees of abduction of the humerus the upper trapezius enters into strong fixation action To palpate the supraspinatus the trapezius should be as relaxed as possible This is accomplished by a position of the head (as illustrated) which places the muscle in the relaxed position and by testing before normal upper trapezius fixation occurs

WEAKNESS

The tendon of the supraspinatus is firmly attached to the superior surface of the capsule of the shoulder joint Weakness of the muscle or a rupture of the tendon decreases shoulder joint stability allowing the humerus to drop slightly in relation to the glenoid

CONTRACTURE

(See Posterior Deltoid)

Fig 47 Posterior Deltoid

Patient

Sitting

Fixation

The examiner must stabilize the scapula if the fixation muscles of the scapula are weak The examiner should assist in stabilizing the trunk by fixation against the anterior shoulder girdle as pressure is applied.

Test

Shoulder abduction in slightly posterior plane with the humerus in slight internal rotation Though the anatomical action of the posterior deltoid is abduction and slight external rotation, it is necessary to place the humerus in slight internal rotation in the erect sitting position to obtain maximum action in its anti gravity function Tested in the prone position

the arm should be placed in abduction and external rotation. If the sitting position were modified so that the body inclined diagonally forward, the test then would be to place the humerus in a horizontal abduction position. In relation to the shoulder joint this would represent a position of abduction and external rotation. (The same modification could be applied to the anterior deltoid by inclining the body diagonally backward, but such trunk positions are unstable so not recommended.)

Weakness of Deltoid and Supraspinatus as a Whole

Results in the inability to lift the arm in abduction against gravity. In the presence of deltoid weakness, if the arm remains unsupported in a hanging position, the humerus tends to subluxate downward. The capsule of the shoulder joint permits almost an inch of *separation of the head of the humerus from the glenoid fossa.* In cases of axillary nerve involvement in which the deltoid is weak while the supraspinatus is not affected, the relaxation of the joint is not as marked, but tends to progress if the deltoid strength does not return.

Shortness and Contracture

Rarely seen. Some Erbs palsy cases tend to develop muscle tightness if the arm remains splinted in abduction for too long a period.

FIG 48 Coraco-brachialis

PATIENT

Sitting or supine

FIXATION

If the trunk is stable no fixation by the examiner is necessary

TEST

Shoulder flexion with the elbow completely flexed the humerus in slight external rotation, and forearm supinated

PRESSURE

Against the antero-medial surface of the lower end of the humerus in a downward slightly outward direction

WEAKNESS

Diminishes the strength of shoulder flexion particularly in movements of the arm which involve flexion of the shoulder with the elbow flexed (as for example in combing the hair)

SHORTNESS

When this muscle shortens as a result of various occupational causes the coracoid process of the scapula is depressed forward when the arm is dropped down at the side Such muscle tightness is an important contributing factor in many cases of arm pain. (See also Pectoralis Minor)

Fig 49 Pectoralis Minor

Patient

Supine

Fixation

None by the examiner unless the abdominal muscles are weak in which case the rib-cage on the same side should be held firmly down

Test

Forward thrust of the shoulder with the arm at the side (The patient must exert no downward pressure on the hand to force the shoulder forward)

Pressure

Against the anterior aspect of the shoulder downward pressure in the direction of the table (The serratus anterior superior assists the pectoralis minor in depressing the scapula forward)

Weakness

The strength of backward extension of the humerus is dependent upon fixation of the scapula by the rhomboids and levator scapulae posteriorly and the pectoralis minor anteriorly With weakness of the minor the strength of arm extension is diminished

With the scapula stable in a position of good alignment the pectoralis minor acts as an accessory muscle of inspiration Weakness of this muscle will increase respiratory difficulty in patients already suffering from involvement of respiratory muscles

Contracture

With the origin of this muscle on the ribs and the insertion on the coracoid process of the scapula a contracture of this muscle tends to depress the coracoid process of the scapula forward and downward Such muscle contracture is an important contributing factor in many cases of arm pain With the cords of the brachial plexus and the axillary blood vessels lying between the coracoid process and rib-cage the contracture of the pectoralis minor produces an impingement on these large vessels and nerves producing a Coracoid Pressure Syndrome

Fig 50 Pectoralis Major clavicular portion

Patient

Supine

Fixation

The examiner holds the opposite shoulder firmly on the table (The triceps maintain the elbow in extension)

Test

Horizontal adduction of the humerus toward the sternal end of the clavicle with the humerus in slight internal rotation

PRESSURE

With the elbow extended against the fore arm in an outward and slightly downward direction

WEAKNESS

Lessens the ability to draw the arm in horizontal adduction across the chest making it difficult to touch the hand to the opposite shoulder Decreases strength of shoulder flexion and internal rotation

SHORTNESS

The range of motion in horizontal abduction and external rotation of the shoulder is decreased As the humerus is drawn into a forward shoulder position the scapula is abducted from the spine

Fig 51 Pectoralis Major sternal portion

Patient

Supine

Fixation

The examiner places one hand on opposite iliac crest to hold pelvis firmly on the table (In cases of abdominal weakness fixation must be applied to the thorax) (The triceps maintains the elbow in extension)

Test

With the elbow extended oblique adduction of the arm toward the opposite iliac crest

Pressure

Against the forearm in an upward-outward direction.

Weakness

Lessens the strength of shoulder internal rotation and oblique adduction (toward the opposite hip) There is a loss of continuity of the muscle pull from the pectoralis to external oblique and internal oblique on the opposite side with the result that chopping or striking movements are difficult

Shortness

The humerus is drawn into an internally rotated and a forward-shoulder position with resultant abduction of the scapula and depressed position of the chest There is a *forward depression of the shoulder girdle by the* pull of the pectoralis major on the humerus which often accompanies the pull of a tight pectoralis minor on the scapula The range of motion of arm extension overhead is limited

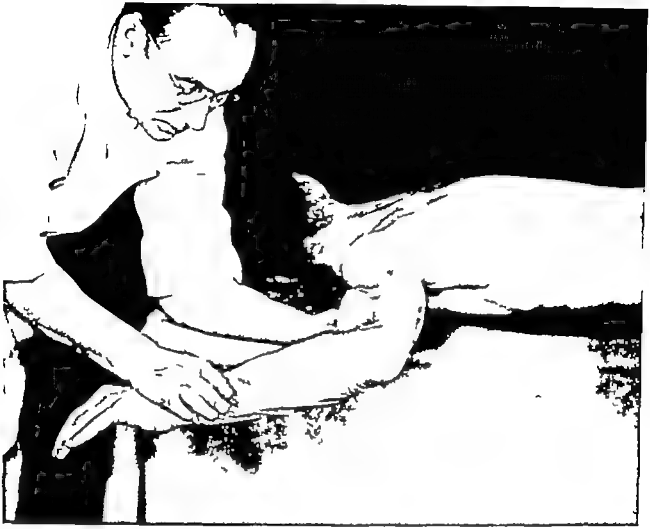


Fig 52 Shoulder external rotators

Patient

Prone

Fixation

The upper arm rests on the table The examiner places one hand under the arm near the elbow and stabilises the humerus. He insures a rotation action by preventing adduction or abduction motion His hand cushions against the table pressure This test requires strong fixation by the scapular muscles particularly the middle and lower trapezius

Test

External rotation of the humerus (with the elbow flexed at right angle)

Pressure

Using the forearm as a lever pressure is applied in the direction of internally rotating the humerus

Note

For the purpose of objectively grading a weak external rotator group and for palpation of the rotator muscles, this test is preferred over the teres minor and infraspinatus test in supine position which follows. For action of the two above rotators without much assistance from the posterior deltoid and without the necessity of maximal trapezius fixation the test in supine position is preferred

FIG 53 Teres Minor and Infraspinatus

PATIENT

Supine

FIXATION

Counter pressure is applied by the examiner against the inner aspect of the distal end of the humerus in order to insure a rotation motion

TEST

External rotation of the humerus (with the elbow flexed to a right angle)

PRESSURE

Using the forearm as a lever pressure is applied in the direction of internally rotating the humerus

WEAKNESS

The humerus assumes a position of internal rotation Interferes with external rotation particularly in arm movements which require external rotation in anti-gravity positions

SHORTNESS OR CONTRACTURE

Rarely seen Some Erbs palsy cases appear to develop such tightness from position in statue-of liberty splint.

FIG 54 Shoulder internal rotators

PATIENT

Prone

FIXATION

The upper arm is resting on the table The examiner places one hand under the arm near the elbow and stabilizes the humerus He insures a rotation action by preventing adduction or abduction motion. His hand cushions against the table pressure

TEST

Internal rotation of the humerus (with the elbow flexed to a right angle)

PRESSURE

Using the forearm as a lever pressure is applied in the direction of externally rotating the humerus

NOTE

For the purpose of objectively grading a weak internal rotator group this test in the prone position is prefered over the alternate test in supine position (See next figure.) For maximum strength test, the alternate test is preferred because less scapular fixation is required

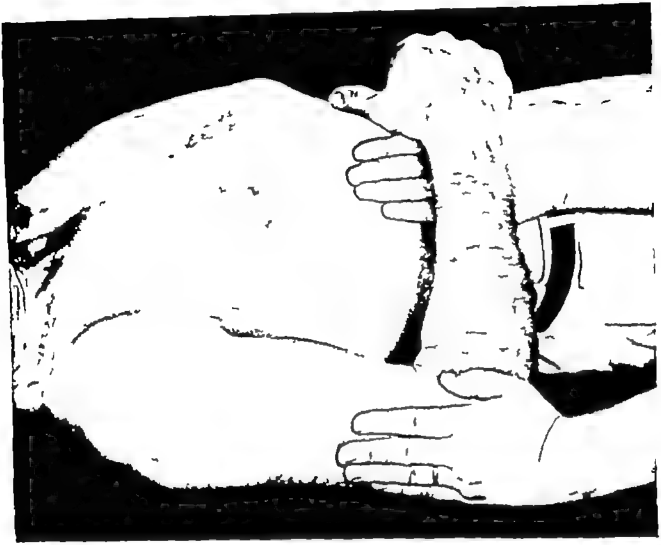


Fig 55 Shoulder internal rotators (alternate test)

Patient

Supine

Fixation

Counter pressure is applied by the examiner against the outer aspect of the distal end of the humerus in order to insure a rotation motion

Test

Internal rotation of the humerus with arm at the side (and the elbow flexed to a right angle)

Pressure

Using the forearm as a lever pressure is applied in the direction of externally rotating the humerus

Weakness

In as much as the internal rotators are also the strong adductors the ability to perform both internal rotation and adduction is decreased

Shortness

(See figures 57b and 58)

Note

Chief muscles acting in this shoulder internal rotation test are latissimus dorsi pectoralis major subscapularis teres major

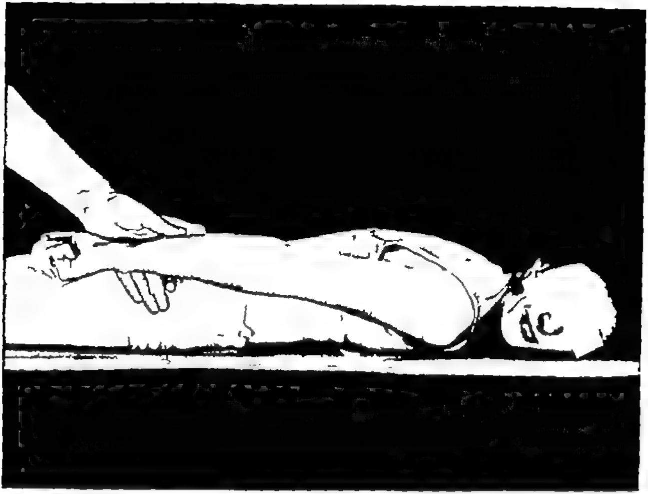


Fig 56 Latissimus Dorsi

PATIENT

Prone

FIXATION

None necessary

TEST

Adduction of the arm, with extension in the internally rotated position.

PRESSURE

Against the forearm, in the direction of abduction and slight flexion of the arm.

WEAKNESS

(In relation to trunk, see p 210)

Weakness of the latissimus dorsi interferes with many activities which involve adduction of the arm toward the body or the body toward the arm. This muscle is extremely important in relation to movements such as climbing, walking with crutches or hoisting the body up on parallel bars in which the muscles act to lift the body toward the fixed arm. Forceful arm movements in swimming rowing and chopping are largely dependent on the strength of this muscle

All adductors and internal rotators function in these strong movements but the latissimus is probably of major importance

SHORTNESS

Results in a limitation of arm extension overhead Tends to depress the shoulder down and forward

(a)

(b)

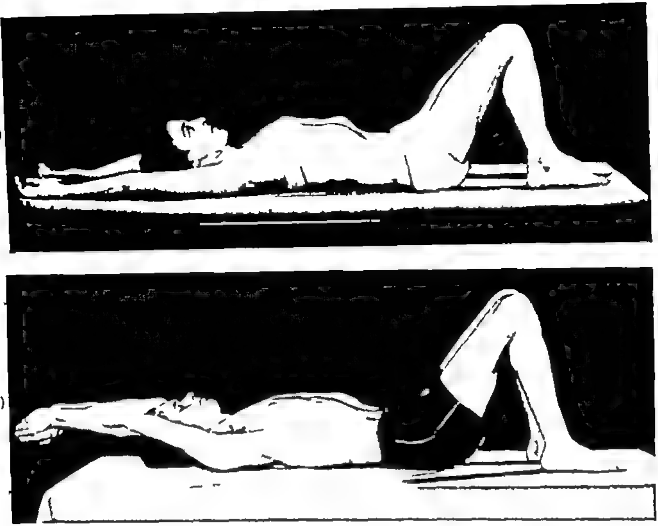


Fig. 57 Test for tightness of shoulder adductors and internal rotators

(a) With no shortness in shoulder adductors and internal rotators the shoulder joint can be completely extended in the overhead position The absence of pectoralis minor tightness is denoted by the fact that the posterior shoulder girdle lies flat against the table

(b) The presence of tightness in the latissimus dorsi pectoralis major and pectoralis minor is obvious in this subject The shoulder joint is incompletely extended overhead, and the posterior shoulder girdle does not lie flat against the table. The influence of pectoralis minor tightness on shoulder joint extension overhead may be demonstrated by having a flexible subject hold the shoulder girdle in the position of the pectoralis minor test and then having the examiner attempt to take the arm into overhead position.

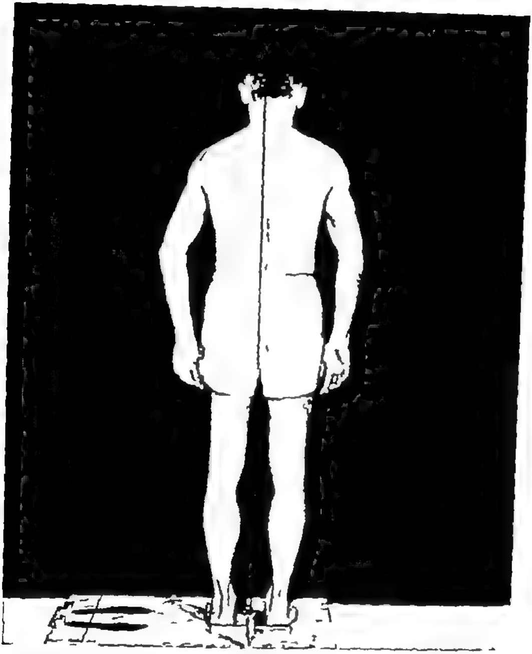


FIG 58 Effect on posture of shortness in adductors and internal rotators of the shoulder joint

With shortness of shoulder adductors and internal rotators the arms hang at the sides in an internally rotated position The palms of the hands face backward, instead of toward the body as they do in a normal easy posture. The over-development of these muscles is quite frequently seen in athletic individuals

Fig 59 Upper Trapezius

Patient

Sitting

Fixation

None necessary

Test

Elevation of the acromial end of the clavicle and extension of the head toward the elevated shoulder with the face rotated in the opposite direction

Pressure

Against the elevation of the shoulder and the postero-lateral neck extension

Weakness

Lessens the ability to approximate the acromial end of the scapula toward the occiput or the occiput toward the shoulder Interferes with abduction or flexion of the humerus above shoulder level. (See p 128 for weakness of entire trapezius)

Shortness

Results in a position of elevation of the shoulder girdle (commonly seen in prize fighters) In a faulty posture with forward head and kyphosis the upper trapezius muscles are short and tense

Contracture

Frequently seen in torticollis cases The left upper trapezius is usually contracted along with a contracture of the left sterno-cleido-mastoid and scaleni (The splenius on the opposite side posteriorly is contracted) In a left torticollis the face is rotated toward the right and the head is tilted toward the left Thus a left torticollis produces a right cervical scoliosis

Fig 60 Middle Trapezius

PATIENT

Prone

FIXATION

None necessary on the part of the examiner but the elbow extensors and the shoulder muscles particularly the posterior deltoid, teres minor and infraspinatus must give the necessary fixation to use the arm as a lever

TEST

Adduction of the scapula with the inferior angle rotated slightly forward To obtain this position of the scapula and to obtain leverage for pressure in the test the arm is placed in horizontal abduction with the elbow extended and the shoulder in external rotation (as denoted by the position of the hand with the palm facing upward toward the head)

PRESSURE

Against the forearm, in a downward direction toward the table [If the posterior shoulder muscles are weak, the arm is dropped over the side of the table]

FIG 61 Error in testing middle trapezius

If a position of internal rotation of the humerus and elevation of the scapula is permitted in testing for the middle trapezius it ceases to be a trapezius test As seen in this illustration when the scapula rides upward it is adducted by rhomboid action rather than by middle trapezius action The distinction of muscle actions as seen in comparing this and the preceding illustration is an example of what is meant by obtaining the specific action in which a muscle is the prime mover

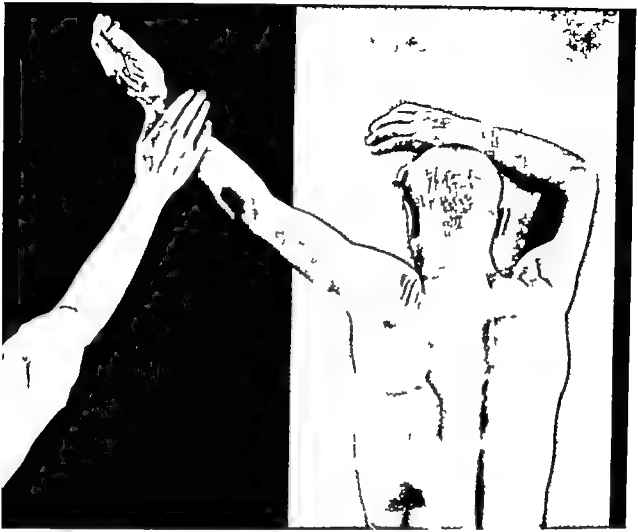


Fig 62a Lower Trapezius

Patient

Prone

Fixation

None is necessary on the part of the examiner but the elbow extensors and shoulder muscles particularly posterior deltoid must give the necessary fixation to use the arm as a lever in this test

Test

Adduction and depression of the scapula with the inferior angle rotated forward To obtain this position of the scapula and to obtain leverage for the pressure in the test the patient s arm is placed in diagonal extension overhead with the shoulder externally rotated (as denoted by the position of the hand)

Pressure

Against the forearm, in a downward direction toward the table [If the posterior deltoid is weak the arm is not extended overhead but is dropped over the side of the table with shoulder externally rotated The scapula is placed in the test position (that is adduction and depression) Pressure is applied against the scapula itself in an upward-outward direction.]

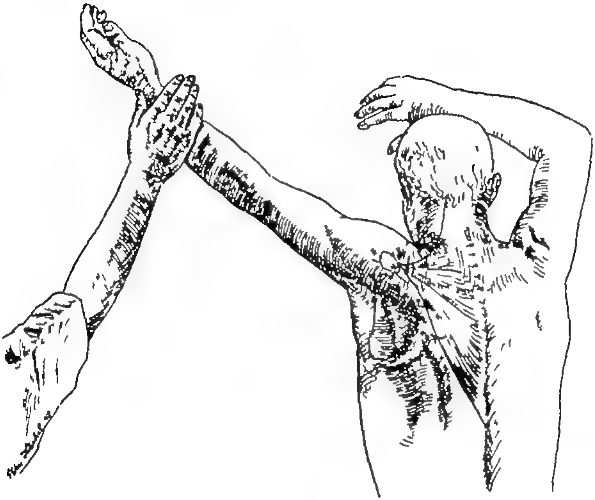


Fig 62b Lower Trapezius

The degree of abduction of the humerus in the test of the lower trapezius is determined by the line of pull of the muscle fibers as denoted in the accompanying illustration

Weakness (Lower and Middle)

The scapula tends to ride upward and outward permitting a forward shoulder position The resultant faulty position of the shoulder is a contributing factor in some cases of arm pain Upper back pain frequently results from a stretch weakness and fatigue of the middle and lower trapezius Weakness interferes with abduction or flexion of the humerus above shoulder level

Contracture

Rarely seen

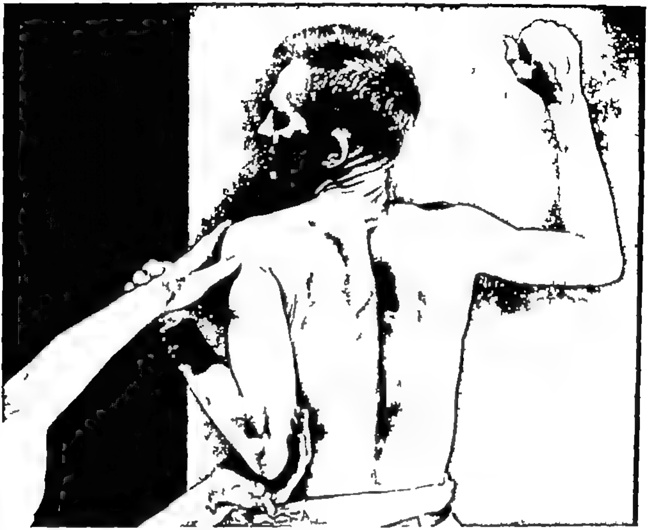


Fig 63 Rhomboids Major and Minor and Levator Anguli Scapulae

Patient

Prone

Fixation

None is necessary on the part of the examiner but it is assumed that the adductors of the shoulder joint have been tested and found to be strong enough to hold in using the arm for leverage in this test

Test

Adduction and elevation of the scapula with backward rotation of the inferior angle To obtain this position of the scapula and to obtain leverage for pressure in the test the arm is placed in the position as illustrated The humerus is adducted toward the side of the body externally rotated and slightly extended with the elbow flexed

Pressure

The examiner applies pressure with one hand against the patient's arm in the direction of abducting the vertebral border of the scapula from the spine and against the patient's shoulder with the other hand in the direction of derotation (to rotate the inferior angle outward)

NOTE

(If the shoulder muscles are weak the examiner places the scapula in the test position and attempts to derotate the scapula with outward-downward pressure.) Like the trapezius the rhomboids do not act directly on the arm but as pressure is applied against the arm in test position they stabilize the scapula in that line of pull. The latissimus dorsi may strongly adduct the arm but has little influence on the scapula so the fixation of the scapula must be observed and not merely the ability to adduct the arm.

WEAKNESS

The scapula abducts and the inferior angle rotates outward. The strength of adduction and extension of the humerus is diminished by loss of rhomboid fixation of the scapula. Ordinary function of the arm is affected less by loss of rhomboids than by loss of either trapezius or serratus anterior.

CONTRACTURE

The scapula is drawn into a position of adduction and elevation. Contracture tends to accompany paralysis or weakness of serratus anterior.

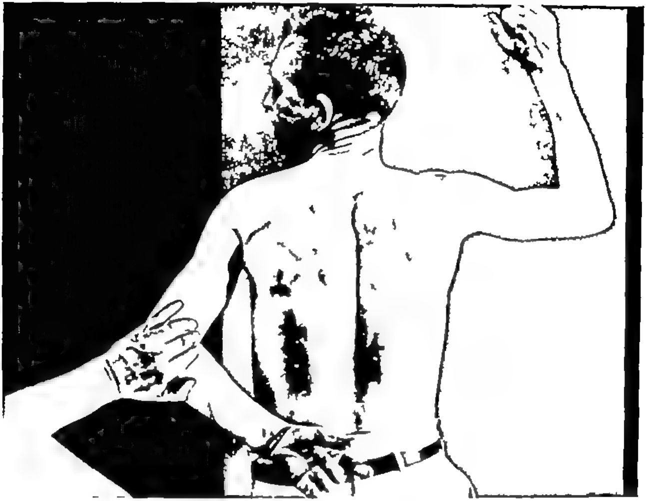


Fig 64. Teres Major

Patient

Prone

Fixation

Usually none is necessary because the weight of the trunk is sufficient fixation If necessary the opposite shoulder may be held down.

Test

Extension and adduction of the humerus in the internally rotated position with the hand resting on the posterior iliac crest.

Pressure

Against the arm above the elbow in a downward outward direction

Note

The patient should not be permitted to thrust the shoulder down and forward to bring in latissimus on this test

Weakness

Diminishes the strength of internal rotation and backward extension of the humerus

Shortness

Prevents full range of external rotation and abduction of the humerus. With tight teres major the scapula will begin to rotate forward almost simultaneously with abduction. Scapular movements which accompany shoulder abduction are influenced by the degree of muscle shortness of the teres major (and subscapularis) Normal variations in scapular motion are closely related to the normal (acquired) variations in length of these muscles.

Fig. 65 Serratus Anterior (standing)

PATIENT

Standing

FIXATION

None necessary

TEST

Abduction of the scapulae Standing facing a wall the patient places his hands against the wall at shoulder level or slightly above with elbows straight and pushes hard against the wall

PRESSURE

The weight of the upper trunk acts as resistance in this test movement The scapulae are the fixed points and the serratus is called on to act in such a way that the chest is drawn backward toward the scapulae (The scapula is pulled forward toward the rib cage in a forward thrust of the arm described in the test below)

WEAKNESS AND CONTRACTURE

(See series of illustrations following the tests)

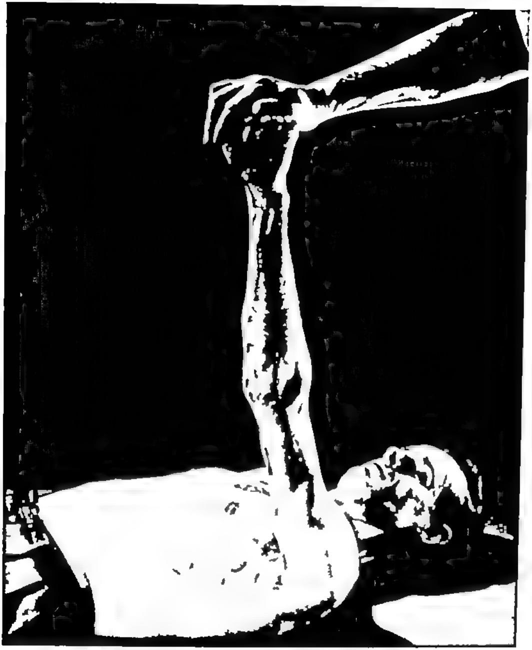


FIG 66 Serratus Anterior (supine)

PATIENT

Supine

FIXATION

None necessary unless the shoulder or elbow muscles are weak, in which case the examiner will support the arm in the perpendicular position as the patient shoves it upward

TEST

Abduction of the scapula in a forward thrust of the arm. Patient is supine and the arm is held in a position perpendicular to the body and shoved upward The abducted position of the scapula is held against the examiner's pressure

PRESSURE

Against the patient's fist in the downward direction toward the table

Fig 97 Serratus Anterior (sitting)

Patient

Sitting

Fixation

None should be necessary by the examiner if the trunk is stable but the flexors of the shoulder must be strong to use the arm as a lever in this test

Test

Forward flexion of the humerus in the position of approximately 120 degrees flexion

Pressure

Against the upper arm in a downward direction, and against the scapula in a backward direction

Note

Three tests have been outlined for the serratus because it is often necessary and advisable to employ more than one test to get an accurate check on this muscle The first (in standing) is a strenuous test and will usually only differentiate between normal and weak Associated muscle involvements will determine which of the other two tests is the more satisfactory in determining the degree of serratus weakness

Fig 08a. Paralysis right Serratus Anterior

Figure (a) illustrates the winging of the scapula as seen during the test movement in paralysis of the serratus anterior

FIG. 68b Paralysis right Serratus Anterior

Figure (b) shows the extent of arm raising overhead that is accomplished by this patient

This particular patient was able to raise the arm overhead because the strength of the trapezius was sufficient to compensate for the absence of serratus power However she showed signs of fatigue and decrease in the ability to raise the arm when the movement was repeated five or six times

When the trapezius is not strong enough to rotate the scapula without serratus assistance the patient will not be able to raise the arm overhead

Since there is such a wide range of variation in trapezius strength in non-paralytic individuals (see p 15) there will be variations in the ability to raise the arm in cases of isolated serratus palsy

FIG 69a Paralysis right Trapezius and Serratus Anterior

Figure (a) shows the inability of the patient to raise the arm over head when both the serratus anterior and the trapezius are weak. The degree of winging out of the scapula from the rib cage makes it appear as if the rhomboids were also weak.

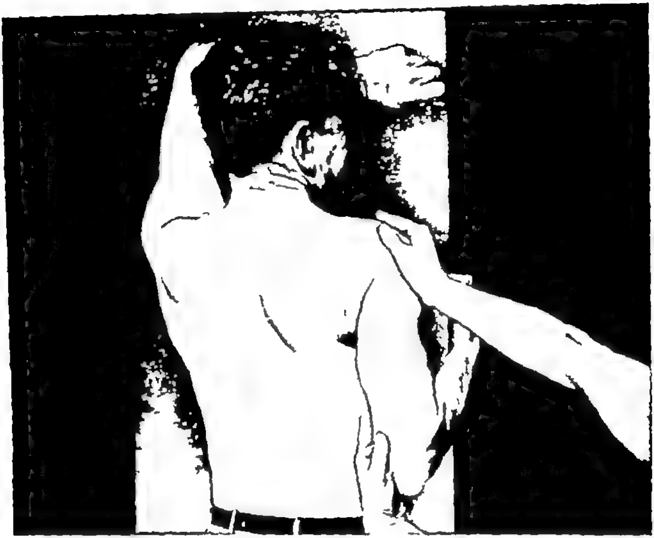


Fig 69b Paralysis right Trapezius and Serratus Anterior

Figure (b) demonstrates on this same patient the strength of the rhomboids in adducting and stabilizing the scapula

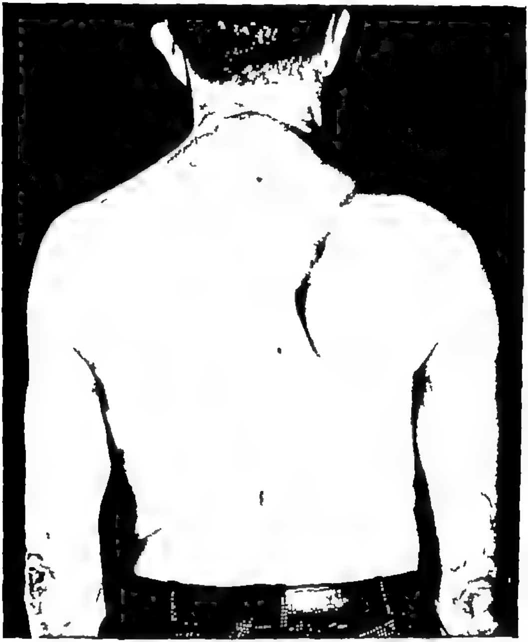


Fig 70 Posture of the shoulder in paralysis of right Trapezius and Serratus Anterior

This figure shows the faulty position of the scapula that results from paralysis of both trapezius and serratus anterior

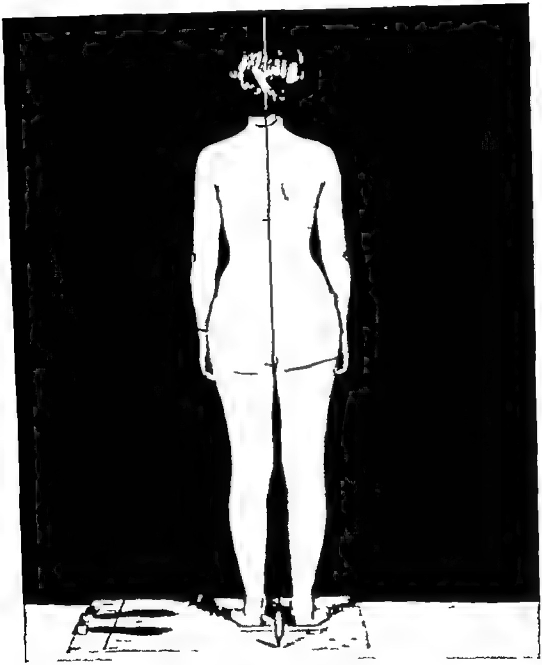


FIG 71 Mild Serratus weakness

The accompanying illustration shows the posture of the shoulders as seen in cases of mild serratus weakness There is slight winging of the scapula The individual may not be aware of any functional disability but may complain of fatigue in the region of the trapezius if required to do much lifting with the arms The trapezius is forced to compensate for the serratus weakness in scapular rotation

CHAPTER IV

LOWER EXTREMITY MUSCLES

FIG 72 Flexor Hallucis Longus

PATIENT

Supine or sitting

FIXATION

The examiner stabilizes the metatarso-phalangeal joint in neutral position and maintains a neutral position of the foot and ankle *

TEST

Flexion of the distal phalanx of the big toe

PRESSURE

Against the plantar surface of the distal phalanx in the direction of extension.

* NOTE

Since the flexor longus hallucis is a long muscle passing over the ankle joint the foot and ankle must be maintained in a neutral position. Extreme plantar flexion will restrict the test movement by the tension of opposing toe extensors and plantar flexion and inversion will relax the muscle so that it cannot exert its strongest pull in this test movement If the flexor hallucis brevis is very strong and the flexor hallucis longus weak, the power in the longus cannot be accurately determined unless the metatarso-phalangeal joint is held by the examiner in a neutral or slightly extended position.

WEAKNESS

In weight-bearing a weakness permits a tendency toward pronation of the foot because the medial stability provided by this muscle is lost A weakness causes tendency towards what is commonly called a gastrocnemius limp and interferes with rising on toes

CONTRACTURE

Hammer-toe position of big toe

FIG 73 Flexor Hallucis Brevis

PATIENT

Supine or sitting

FIXATION

The examiner supports the foot proximal to the metatarso-phalangeal joint and maintains a neutral position of the foot and ankle (Plantar flexion of the foot may cause restriction of the test movement by the tension of the opposing long toe-extensor muscles)

TEST

Flexion of the proximal phalanx of the big toe

PRESSURE

Against the plantar surface of the proximal phalanx in the direction of extension.

NOTE

When the flexor hallucis longus is paralyzed and the brevis is active the action of the brevis is clear because the toe flexes at the proximal joint without any flexion of the distal joint When the flexor hallucis brevis is paralyzed and the longus is active, hyperextension occurs at the metatarso-phalangeal joint and the distal joint flexes creating a hammer toe position

WEAKNESS

Allows hammer toe position of big toe Lessens stability of the longitudinal arch

CONTRACTURE

Causes restriction of dorsi flexion of the big toe The proximal phalanx is flexed

Fig 74 Flexor Digitorum Longus

Patient

Supine or sitting (In the presence of gastrocnemius tightness the knee should be flexed to permit a neutral position of the foot)

Fixation

The examiner stabilizes the middle phalanges and maintains a neutral position* of the foot and ankle

Test

Flexion of the distal phalanges of the second third fourth and fifth digits

Pressure

Against the plantar surface of the distal phalanges of the four toes in the direction of extension.

* Note

Since the flexor digitorum longus is a long muscle passing over the ankle joint the foot and ankle must be maintained in neutral position for the test Plantar flexion and inversion will place a tension on opposing long extensors, thereby restricting toe flexion or even in the absence of such opposing tension the position relaxes the muscle being tested to such an extent that it cannot exert its strongest pull in the test.

The flexor digitorum is assisted by the quadratus plantae

Weakness

In weight-bearing weakness permits a tendency toward pronation of the foot due to loss of medial stability at the ankle inclines toward what is commonly called a gastrocnemius limp and interferes with the movement of rising on toes

Contracture

Flexion deformity of distal phalanges of four outer toes with restriction of dorsi-flexion and eversion of foot

Fig 75 Flexor Digitorum Brevis

Patient

Supine or sitting

Fixation

The examiner stabilizes the proximal phalanges and maintains a neutral position of the foot and ankle (Plantar flexion of the foot may cause restriction of the test movement by tension of the opposing long extensor muscles.) If the gastrocnemius and soleus are paralyzed the examiner must stabilize the os calcis which is the point of origin during the toe flexor test.

Test

Flexion of the middle phalanx of the second third fourth and fifth digits

Pressure

Against the plantar surface of the middle phalanx of the four toes in the direction of extension

Note

When the flexor digitorum longus is paralyzed and the brevis is active the toes flex at the middle phalanx while the distal phalanx remains extended

Weakness

The muscular support of the longitudinal and transverse arches is diminished

Contracture

Restriction of dorsi flexion of the toes The middle phalanges flex and there is a tendency toward a cavus if the gastroc-soleus is weak

Fig 76 Lumbricales

Patient

Supine or sitting

Fixation

Examiner stabilizes the mid tarsal region and maintains a neutral position of the foot and ankle

Test

Flexion of the metatarso-phalangeal joints of the 2nd 3rd 4th and 5th digits

Pressure

Against the plantar surface of the proximal phalanges of the four outer toes

Weakness

When the lumbricales are weak and the flexor digitorum longus is active hyperextension occurs at the metatarso-phalangeal joints. The distal joints flex causing a hammer toe position of the four lateral toes. Support of the anterior arch is decreased

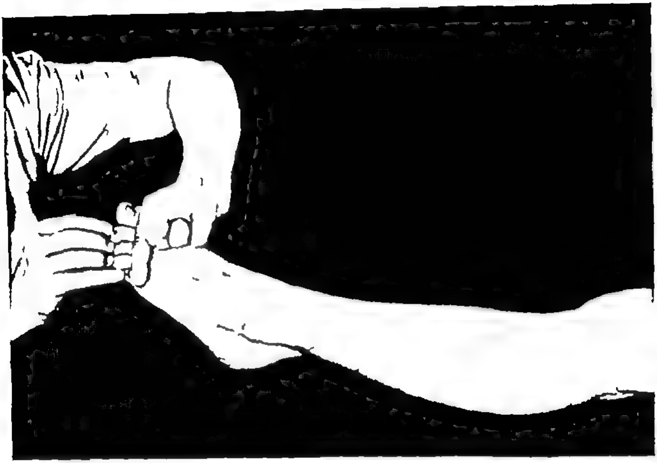


Fig 77 Toe Extensors and Lumbricales

Patient

Supine or sitting

Fixation

The examiner stabilizes the metatarso-phalangeal joints in the neutral position

Test

Extension of the inter phalangeal joints of the four outer toes

Pressure

Against the dorsal surface of the distal phalanges in the direction of plantar flexion

Note

Testing the strength of distal joint extensors is important in understanding the imbalance which lends itself to a hammer toe condition

Weakness

(See Lumbricales)

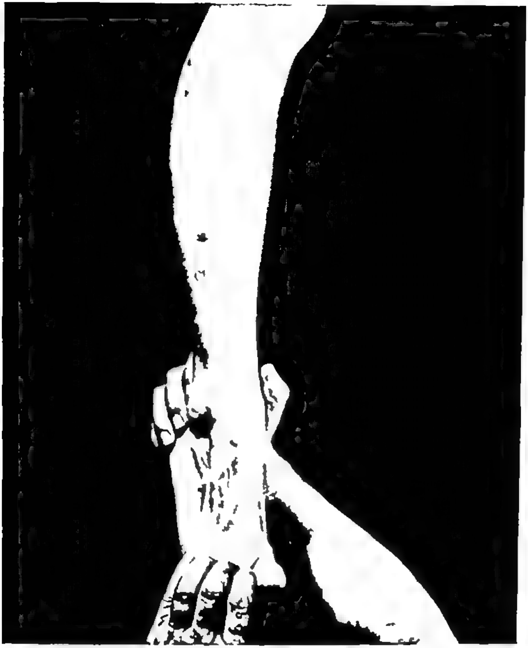


FIG 78a. Extensor Digitorum Longus and Brevis

Fig (a) Muscle test

PATIENT

Supine or sitting

FIXATION

The examiner stabilizes the foot in neutral position (Plantar flexion of the ankle will put tension on the long extensor and dorsal flexion will relax the long extensor thereby influencing the test movement)

TEST

Extension of all joints of the second third fourth and fifth digits

PRESSURE

Against the dorsal surface of the toes in the direction of plantar flexion

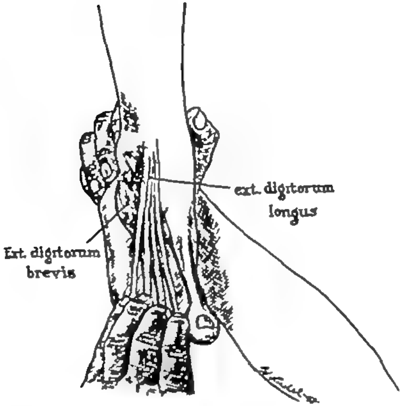


Fig 78b

Fig (b) Line drawing of extensor digitorum brevis (including first slip extensor hallucis brevis), and tendons of extensor digitorum longus

NOTE

Since the brevis fuses with the tendon of the longus to the second third and fourth digits the brevis as well as the longus will extend all joints of these toes

In the absence of a longus a strong brevis will extend the metatarso-phalangeal joint of the first toe and extend all the joints of the second third and fourth toes without any action on the fifth To differentiate between the longus and brevis always look for and palpate the tendon of the longus and the belly of the brevis and try to detect the differences in movement

WEAKNESS

Allows tendency toward drop-foot and anterior foot varus Diminishes strength of dorsi flexion and eversion of foot

The long arch of the foot is supported primarily by the plantar ligaments and muscles But it is altogether possible that the toe extensors give secondary support on the dorsum of the foot at the metatarso-phalangeal joint The weakness of toe extensors that accompanies many flat foot cases is an interesting feature in relation to the collapse of the long arch

CONTRACTURE

Position of eversion and dorsi flexion of the foot

Fig 79 Extensor Hallucis Longus and Brevis

Patient

Supine or sitting

Fixation

The examiner stabilizes the foot in neutral position. (Plantar flexion of the ankle will put too much tension on the long extensor muscle and dorsal flexion will relax the long extensor thereby influencing the test movement.)

Test

Extension of the big toe

Pressure

Against the dorsal surface of the distal and proximal phalanges of the big toe in the direction of plantar flexion

Weakness

Allows the big toe to be in position of plantar flexion. May cause a tendency toward drop-foot

Contracture

Dorsi flexion of the big toe with the head of the first metatarsal driven downward

Note

The absence of an extensor hallucis brevis (first slip of the extensor digitorum brevis) cannot be determined accurately in the presence of a strong extensor hallucis longus. However in the absence of the longus the action of the brevis is clear. The distal phalanx does not extend and the proximal phalanx extends (i.e. dorsi-flexes) in the direction of adduction (toward the mid-line of the foot)

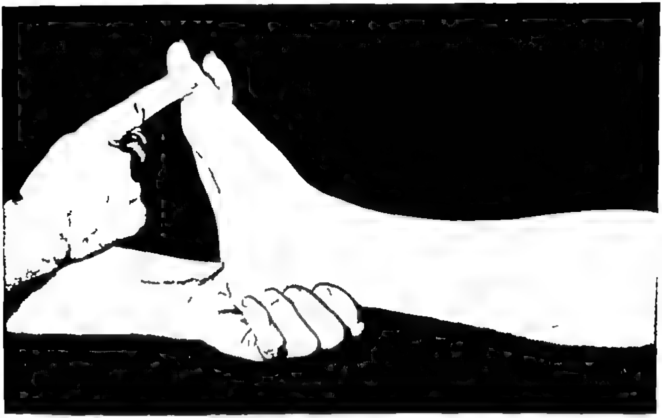


FIG 80 Abductor Hallucis

PATIENT

Supine or sitting

FIXATION

The examiner grips the heel firmly

TEST

If possible abduction of the big toe but this is difficult for the average individual and the action may be demonstrated by having the patient pull the forefoot inward (in the direction of inflare) against pressure by the examiner

PRESSURE

Against the inner side of the first metatarsal and proximal phalanx The muscle can be palpated and often seen along the medial border of the foot

WEAKNESS

Allows anterior foot valgus (or out flare) hallux valgus and medial displacement of the scaphoid

CONTRACTURE

Pulls the foot into anterior foot varus (inflare), with the big toe abducted (from the midline of the foot)

FIG 81 Tibialis Anticus

PATIENT

Supine or sitting (with knee flexed if any gastrocnemius tightness is present)

FIXATION

The examiner supports the lower leg just above the ankle joint

TEST

Inversion of the foot with dorsi flexion of the ankle (foot diagonally up and in) without extension of the big toe

PRESSURE

Against the medial side dorsal surface of the foot in a downward-outward direction

WEAKNESS

Drop-foot with eversion and a tendency toward collapse of the longitudinal arch as associated with a pronated foot

CONTRACTURE

Calcaneo-varus position of the foot

NOTE

Though anterior tibial weakness is found in conjunction with a pronated foot such weakness is seldom found in a congenital flat foot

Fig 82 Peroneus Tertius

PATIENT

Supine or sitting

FIXATION

The examiner supports the lower leg above the ankle joint

TEST

Dorsi flexion of the ankle with eversion of the foot (foot up and out)

PRESSURE

Against the lateral side dorsal surface of the foot in a downward-inward direction

NOTE

The extensor digitorum longus assists the tertius in this test but the pressure must be carefully applied against the pull of the tertius rather than against the toe extension motion

WEAKNESS

Contributes toward a drop-foot in the direction of plantar flexion and inversion

FIG 83 Peroneus Longus and Brevis

PATIENT

Supine with leg internally rotated or side-lying (*on opposite side*)

FIXATION

The examiner supports the lower leg above the ankle joint

TEST

Eversion of the foot with plantar flexion of the ankle (foot diagonally down and out)

PRESSURE

Against the lateral border and sole of the foot in the direction of dorsiflexion and inversion

NOTE

When the peroneus longus pulls strongly the *pull comes from the head of the first metatarsal* causing strong eversion of the sole of the foot with the head of the first metatarsal pulled downward. The peroneus brevis has a strong pull in abduction of the foot but much less than the longus in eversion of the sole of the foot

WEAKNESS

Allows a varus position of the foot inflare of the forefoot and lessens the ability to rise on toes

Lateral stability of the ankle is decreased.

CONTRACTURE OF THE LONGUS

Valgus or pronated position of the foot with *the head of the first metatarsal pulled downward* in non weight-bearing or the forefoot drawn into out-flare in weight-bearing positions

Fig 84 Tibialis Posticus

PATIENT

Supine with leg in external rotation

FIXATION

The examiner supports the lower leg above the ankle joint

TEST

Inversion of the foot with plantar flexion of the ankle (foot diagonally down and in)

PRESSURE

Against the medial side and plantar surface of the foot in the direction of dorsl flexion of the ankle and eversion of the sole of the foot

NOTE

If the flexor hallucis longus and flexor digitorum longus are being substituted for the tibialis posterior the toes will be strongly flexed as pressure is applied

WEAKNESS

Pronation of the foot collapse of the longitudinal arch forefoot valgus Inclines toward what is commonly called a gastrocnemius limp and interferes with the ability to rise on toes

CONTRACTURE

Equino-varus position in non weight-bearing and a supinated position of the heel with anterior foot varus in weight-bearing

FIG 85 Soleus

PATIENT

Prone with the knee flexed 90 degrees or more

FIXATION

The examiner supports the lower leg proximal to the ankle

TEST

Plantar flexion of the ankle (without inversion or eversion of the foot)

PRESSURE

Against the os calcis (as illustrated) in the direction of pulling the heel plantarward

NOTE

Inversion of the foot shows substitution of tibialis posticus and toe flexors Eversion shows substitution of peroneals Extension of the knee is evidence of attempting to assist with gastrocnemius (that is the gastrocnemius being thrown out by knee flexion the patient will attempt to extend the knee in order to bring it into action)

WEAKNESS

Permits a calcaneous position of the foot and predisposes toward a cavus Inability to rise on toes Permits a forward displacement of body weight in standing With the foot as a fixed point in standing the insertion of the soleus muscle on the os calcis becomes the fixed point for action of this muscle in maintaining normal alignment of the lower leg in relation to the foot The deviation that results from weakness of the soleus may appear as a slight knee flexion fault in posture but more often results in an anterior displacement of the body weight from the normal plumb-line distribution (as seen when the plumb-line is hung slightly anterior to the outer malleolus) (See fig 88)

A non paralytic injury type of weakness may result from sudden trauma as in landing from a jump in position of ankle and knee flexion or gradual trauma from repeated deep-knee bending The gastrocnemius escapes the stretch because of the knee flexion

CONTRACTURE

Equinus position of the foot in weight bearing and non weight bearing

SHORTNESS

A tendency toward hyper-extension of the knee in the standing position The tightness is compensated for in walking by toeing out so that weight is transferred from postero-lateral heel to antero-medial forefoot

Fig 80. Gastrocnemius

Patient

Prone with knee extended, and the foot projecting over the end of the table.

Fixation

The weight of the extremity resting on a firm table should be sufficient fixation of the part

Test

Plantar flexion of the foot with emphasis on pulling the heel upward more than pushing the forefoot downward (This test movement does not attempt to isolate the gastrocnemius action from other plantar flexors but the presence or absence of a gastrocnemius can be readily determined by careful observation during the test)

Pressure

For maximum pressure in this position it is necessary to apply pressure against the forefoot as well as against the os calcis If the muscle is weak, pressure against the os calcis is sufficient.

The gastrocnemius can usually be seen and can always be palpated if it is contracting during the plantar flexion test. Movements of the toes and forefoot should be carefully observed during the test to detect substitutions. The patient may be able to plantar flex the anterior part of the foot by toe flexors, tibialis posticus and peroneals without a direct upward pull on the heel by the tendo Achillis. If the gastrocnemius and soleus are weak, the heel will be "pushed" up secondary to plantar flexion of the anterior part of the foot rather than "pulled" up simultaneously with the plantar flexion of the forepart of the foot. If pressure is applied to the heel rather than to the ball of the foot, it is possible to isolate partially the combined action of the gastrocnemius and soleus from the other plantar flexors. (Movement of the foot toward eversion or inversion will show imbalance in opposing lateral muscles and, if pronounced, will show an attempt to substitute the peroneals or tibialis posticus for the gastrocnemius and soleus.)

Action of the gastrocnemius often can be demonstrated in the knee flexion test when the hamstrings are weak. In the prone position with the knee fully extended, the patient is asked to bend the knee against resistance. If the gastrocnemius is strong, there will be plantar flexion at the ankle as the gastrocnemius acts to initiate knee flexion. When the gastrocnemius is weak and stretched, the foot is pulled into dorsi flexion to place slight tension on the gastrocnemius so it can act in knee flexion.

WEAKNESS

Permits a calcaneous position of the foot if the soleus is also weak, and a hyperextended position of the knee in non weight bearing. In standing, results in hyperextension of the knee and inability to rise on toes. In walking, the inability to transfer weight normally results in a gastrocnemius limp.

CONTRACTURE

Equinus position of the foot and flexion of the knee.

SHORTENING

Restriction of dorsi flexion of the ankle when the knee is extended, and restriction of knee extension when the ankle is dorsi flexed. Tightness limits the normal flexion of the lower leg in relation to the dorsum of the foot as in the transfer of weight during a step and results in a tendency toward toeing-out in walking.

MUSCLES WHICH ACT IN PLANTAR FLEXION

Muscles	Action
Soleus Gastrocnemius Plantaris	Ankle plantar flexors (tendo Achillis group)
Tibialis Posterior Peroneus Longus Peroneus Brevis	Foot and ankle plantar flexors
Flexor Hallucis Longus Flexor Digitorum Longus	Toe, foot and ankle plantar flexors.

FIG 87 Ankle and foot plantar flexors

PATIENT

Standing (Patient may steady himself with a hand on the table but should not take any weight on the hand)

TEST

Patient rises on toes pushing the body weight directly upward

NOTE

Inclining the body forward and flexing the knee is evidence of weakness the patient is attempting to clear the heel from the floor by tension of the plantar flexors as the body weight is thrown forward

TIGHTNESS

Constant wearing of high heeled shoes by women tends to develop a muscle tightness of the tendo Achillis group of plantar flexors

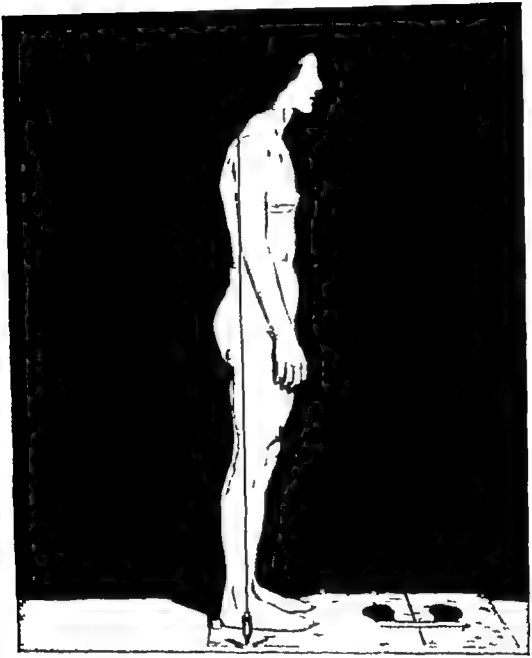
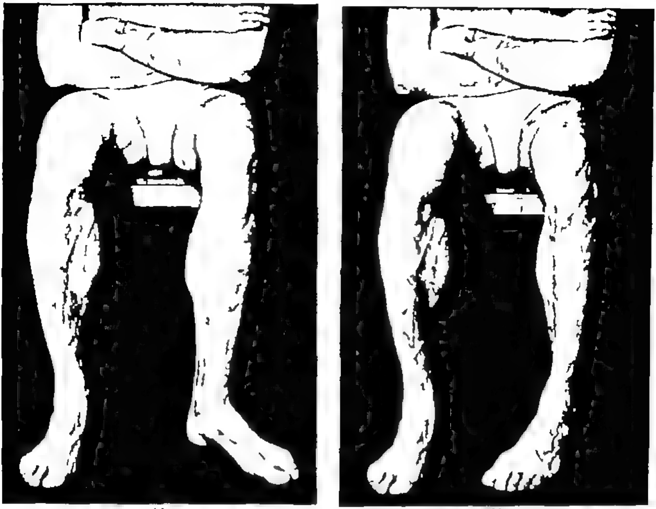


Fig 88 Postural deviation associated with soleus weakness

The soleus is an important muscle in relation to the upright position. In motion this muscle aids in plantar flexing the foot In standing it aids in holding the lower leg back in normal alignment with the foot.

In poliomyelitis patients a strong soleus action may help compensate for a weak quadriceps by pulling the leg back in passive knee extension



(a) (b)

Fig 89 Popliteus

The position of maximum external rotation of the lower leg on the femur is illustrated by (a) The action of the popliteus in internally rotating the lower leg on the femur is illustrated by (b) This movement is not used as a test for the purpose of grading the popliteus but may be used to indicate whether the muscle is active or not

Action

Internally rotates the lower leg on the femur flexes the knee and acts as a posterior knee-joint ligament

Weakness

May result in hyperextension of the knee and external rotation of the lower leg on the femur A popliteus weakness is usually found in instances of imbalance between the outer and *inner hamstrings in which the inner hamstrings* are weak and the outer are strong

Shortness

Results in slight flexion of the knee and internal rotation of the lower leg on the femur

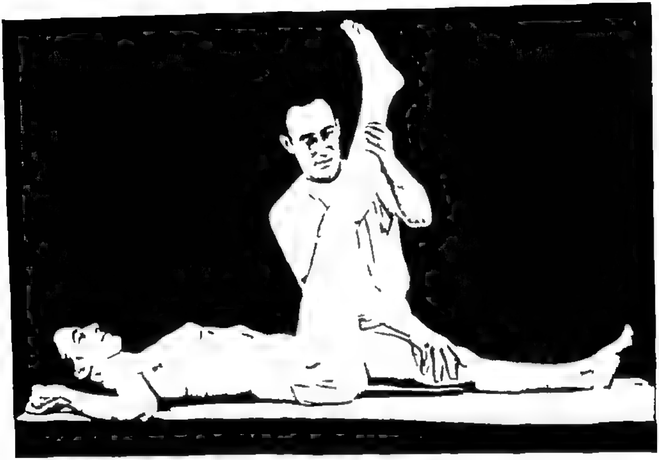


FIG 90 Test for hamstring tightness

The length of the hamstring muscles can be determined by the straight leg raise As illustrated passive hip flexion to approximately an 80 degree angle with the table may be considered normal range

Certain precautions must be taken in using the amount of hip flexion as the gauge of hamstring tightness The examiner must be sure that the straight leg raise movement is one of maximum hip flexion but not one of more than actual hip flexion An apparent hamstring tightness may result from the following

If the (left) hip flexors are short and the left leg is forced down on the table the low back will be forced into hyperextension Then as the opposite (right) leg is passively flexed in the straight leg raising movement there will appear to be hamstring restriction that may not be actual In such a case the (left) leg should be allowed to flex at the hip to the degree that will allow the lumbar spine to flatten on the table The leg should be stabilized in that degree of flexion during the straight-leg raise of the opposite leg

A low back erector spinae tightness will produce the same picture as a hip flexor tightness and should be handled in the same manner that is by allowing sufficient flexion of the opposite leg to keep the back flat

In the absence of hip flexor and erector spinae tightness the opposite leg must be held firmly down on the table (as illustrated) to prevent occurrence of abnormal pelvic tilt as described in the following paragraph

A hamstring tightness may be obscured if the apparent range of hip flexion is increased by tilting the pelvis more posteriorly after maximum hip flexion is completed in the straight leg raise movement Holding the opposite leg down will limit the pelvic tilt to a neutral (back flat) position

Fig 91 Inner hamstrings and gracilis

PATIENT

Prone

FIXATION

The weight of the body is usually sufficient fixation in this test but if there is instability one hand of the examiner should press downward on the buttocks opposite the leg being tested

TEST

Flexion of the knee with the thigh in slight internal rotation and the lower leg inwardly rotated on the thigh

PRESSURE

Against the lower leg proximal to the ankle in a downward-outward direction.

The inner and outer hamstrings in the test positions as outlined are required to hold a

position of nearly maximum contraction Under ordinary circumstances the synergic hip flexor action accompanies the hamstring action in knee flexion. One should not expect the subject to hold knee flexion against the same amount of pressure with the hip extended (in the prone position) that he could resist with the hip flexed (as in sitting) The frequent occurrence of muscle cramping' during the *hamstrings test on non-paralytic individuals* is evidence of too much knee flexion in proportion to the amount of pressure In other words the degree of knee flexion should be less if very strong pressure is applied For maximum pressure hip flexion should be permitted.

NOTE

(The action of the Gracilis along with the Inner Hamstrings is illustrated in the next figure) Weakness of popliteus and gastrocnemius may interfere with initiating knee flexion Substitution of sartorious action will appear in the form of hip flexion as knee flexion is *initiated* A tight rectus femoris limiting knee flexion range of motion will cause hip flexion as the knee flexion motion is *completed* (Hip flexion in the prone position is seen as an anterior tilt of the pelvis with lumbar hyperextension)

WEAKNESS

Loss of internal-lateral stability of the knee Permits knock knee position with a tendency toward external rotation of the lower leg on the femur (See also Outer Hamstrings regarding weakness of both inner and outer and contracture of both)

Fig 92 Gracilis

The action of the gracilis as a knee flexor is illustrated by this figure It is brought into action by the test position and pressure as used for the inner hamstrings

The difference in knee flexion action between the inner hamstrings and the gracilis would depend on the fact that the gracilis has its origin on the pubis and the inner hamstrings arise from the ischium.

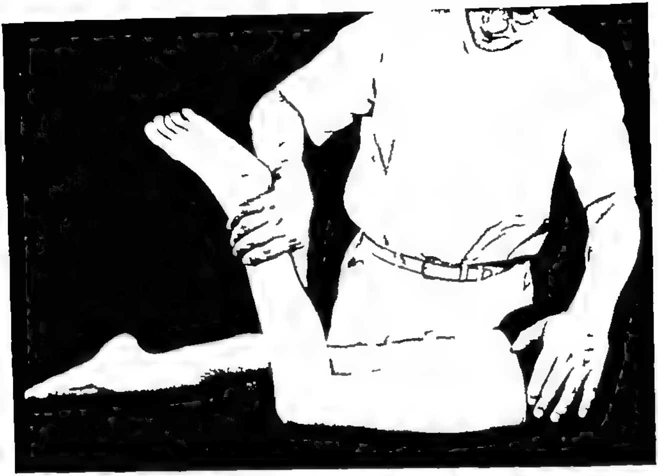


FIG 93 Outer hamstrings

PATIENT

Prone.

FIXATION

The examiner holds the pelvis firmly down on the table

TEST

Flexion of the knee with the thigh in slight external rotation and the lower leg rotated outward on the thigh

PRESSURE

Against the lower leg proximal to the ankle in a downward inward direction

WEAKNESS

Tendency toward loss of lateral stability of the knee allowing a thrust in the direction of bow-leg position in weight-bearing Weakness of both the inner and outer hamstrings permits hyperextension of the knee When this weakness is bilateral the pelvis tilts forward into a position of lordosis of the lumbar spine If the weakness is unilateral a pelvic rotation results

CONTRACTURE

Contracture of both the inner and outer hamstrings results in a position of knee flexion and if the contracture is extreme it will be accompanied by a posterior tilting of the pelvis and a flattening of the lumbar spine A person with such a contracture cannot assume the standing position

SHORTNESS

Restriction of knee extension when the hip is flexed or restriction of hip flexion when the knee is extended Shortness of the hamstrings will permit standing but the standing posture will be characterized by a posterior tilting of the pelvis and a flattening of the lumbar spine

Fig 94. Quadriceps

PATIENT

Sitting on table with knees bent over side of table

FIXATION

The weight of the trunk is usually sufficient to stabilize the patient during this test If the trunk is weak, it is better to have the patient supine during the test

TEST

Extension of the knee without rotation of the thigh

PRESSURE

Against the lower leg above the ankle in the direction of flexion.

NOTE

Inclining the body backward may be evidence of an attempt to release hamstring tension when those muscles are contracted. When the tensor fasciae latae is being substituted for quadriceps it exerts a stronger pull if the hip is extended If the rectus femoris is the strongest part of the quadriceps the patient will lean backward to extend the hip obtaining maximum action of the rectus femoris

WEAKNESS

Interferes with the function of stair climbing or walking up an incline as well as getting up and down from a sitting position The weakness results in knee hyperextension not in the sense that such weakness permits a posterior knee position but in the sense that walking with weak quadriceps requires that the patient lock the knee joint by slight hyperextension Continuous thrust in the direction of hyperextension in growing children may result in a very marked degree of deformity

CONTRACTURE

Knee extension

SHORTNESS

Restriction of knee flexion A shortness of the rectus femoris part of the quadriceps results in restriction of knee flexion when the hip is extended or restriction of hip extension when the knee is flexed

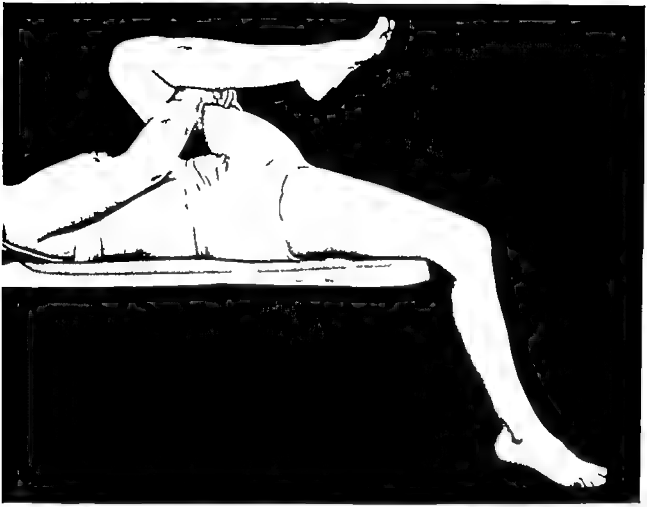


FIG 95a. Test for hip flexor tightness

(a) Subject is supine with one knee flexed on chest to maintain a flat position of the lumbar spine on the table The other knee is flexed over the end of the table The illustration shows normal range of motion of hip flexors with thigh touching the table and knee flexed about 70 degrees

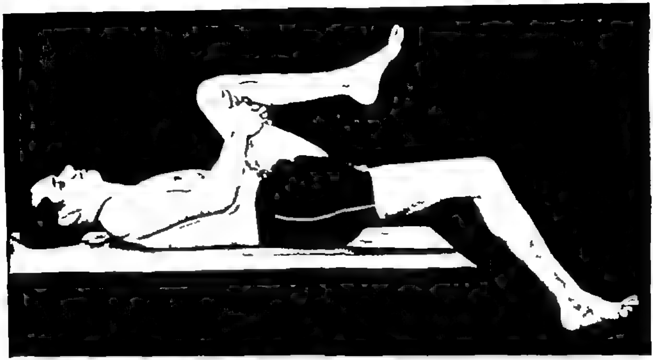


FIG 95b Test for hip flexor tightness

(b) Hip flexor tightness is demonstrated by the limitation of hip extension in this figure The thigh does not drop down to touch the table and the knee extends more than it normally should

A distinction between ilio-psoas and rectus femoris tightness can be determined by this test If tightness is limited to the rectus femoris the thigh can drop down in contact with the table but the knee will extend more. This occurs because the rectus femoris tightness will be referred to the knee when the hip is extended

Fig 96 Hip flexors

PATIENT

Sitting with legs over the side of the table.

FIXATION

The weight of the trunk is usually sufficient to stabilize the patient during this test If the trunk is weak it is better to have the patient supine during the test

TEST

Hip flexion with the knee flexed

PRESSURE

Against the anterior surface of the thigh in the direction of hip extension (that is directly downward toward the table)

WEAKNESS

Results in marked disability in stairclimbing or walking up an incline. Causes difficulty in getting up from a reclining position and flexing the pelvis forward in the sitting position preliminary to rising from a chair. Makes walking difficult because it necessitates substitution of pelvic action by the lateral abdominal muscles for the normal hip flexion motion.

In standing posture, a hip flexor weakness tends to permit an anterior displacement of the pelvis as seen in plumb-line measurements (with plumb-line hung anterior to the outer malleolus).

CONTRACTURE

Hip flexion deformity with increased lumbar lordosis.

SHORTNESS

In the standing position, shortness of the hip flexors is seen as an anterior pelvic tilt with increased lumbar lordosis.

NOTE

External rotation with abduction of thigh as pressure is applied generally is evidence that the sartorius is being substituted for direct hip flexor action, or that the tensor fasciae latae is too weak to counteract the pull of the sartorius and adductors. Internal rotation of the thigh shows tensor stronger than sartorius. If the anterior abdominals do not fix the pelvis to the trunk, the pelvis will flex on the thighs and the hip flexors may hold against strong resistance but not at maximum height. Adduction with slight external rotation is evidence of pectineus and other adductors acting in flexion with little assistance from other flexors.

Fig 97a. Psoas Major

PATIENT

Supine

FIXATION

The examiner gives fixation on the opposite iliac crest

TEST

Hip flexion in a position of slight abduction and slight external rotation The muscle is not seen in the illustration because its insertion is deep between the sartorius and adductor tendons The muscle is differentiated on the basis of its specific line of pull

PRESSURE

Against the antero-medial aspect of the lower leg, in a downward slightly outward direction directly opposite the line of pull of the psoas major from the origin on the lumbar spine to the insertion on the lesser trochanter of the femur

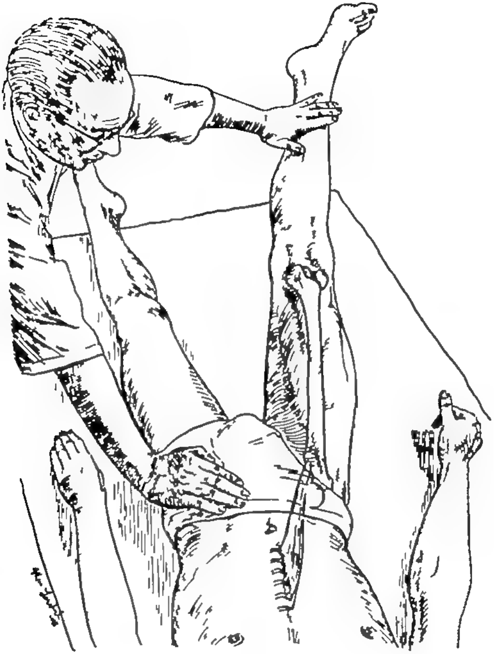


Fig. 97b

This drawing illustrates the line of pull of the psoas major muscle in test position.

WEAKNESS

Same as hip flexor weakness (as described above under Hip flexors, p. 103). In addition, unilateral weakness may be considered a causative factor in a lumbar scoliosis. (See fig. 98.) Bilateral psoas weakness permits a lumbar kyphosis.

Fig 97a. Psoas Major

Patient

Supine

Fixation

The examiner gives fixation on the opposite iliac crest

Test

Hip flexion in a position of slight abduction and slight external rotation The muscle is not seen in the illustration because its insertion is deep between the sartorius and adductor tendons The muscle is differentiated on the basis of its specific line of pull.

Pressure

Against the antero-medial aspect of the lower leg, in a downward slightly outward direction directly opposite the line of pull of the psoas *major from the origin on the lumbar spine* to the insertion on the lesser trochanter of the femur

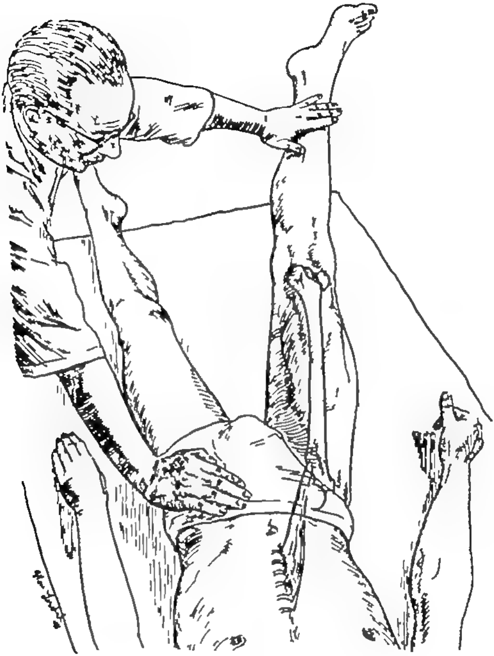


Fig. 97b

This drawing illustrates the line of pull of the psoas major muscle in test position.

WEAKNESS

Same as hip flexor weakness (as described above under Hip flexors p. 163). In addition unilateral weakness may be considered a causative factor in a lumbar scoliosis. (See fig. 98.) Bilateral psoas weakness permits a lumbar kyphosis.

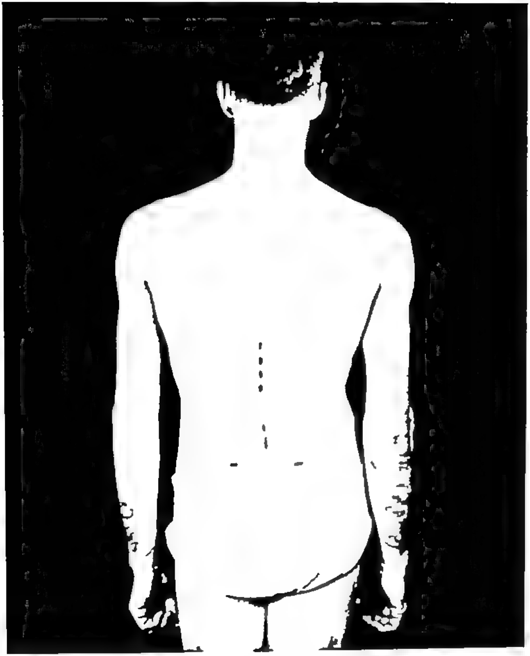


Fig. 98. Scoliosis associated with psoas major weakness.

The subject illustrated showed a weakness of the right psoas (graded about 70% of normal). The muscle fatigued easily in six to eight repeated tests in the psoas test position. Despite the muscular development of the other hip flexors (see fig. 97a.) this weakness was readily detected. The weakness of the psoas major unilaterally permits a deviation of the lumbar spine away from the side of weakness.

Such weakness has been observed numerous times in so-called idiopathic scoliosis cases with a primary lumbar curve. The scoliosis due to psoas weakness is essentially limited to the lumbar region and may exist without noticeable pelvic tilt, as distinguished from a curve due to gluteus medius weakness which is a total C-curve and is associated with pelvic tilt.

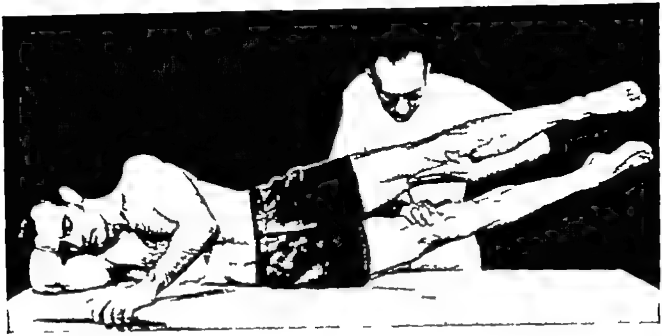


FIG 99 Hip adductors

PATIENT

Side lying (on right side to test right and vice versa) Body in straight line with legs and lumbar spine straight

FIXATION

The examiner holds the upper leg in abduction

TEST

Adduction of the (under) leg upward from the table without rotation flexion or extension of the hip or tilting of the pelvis (Usually performed as a test movement)

PRESSURE

Against the medial aspect of the lower part of the thigh in a downward direction toward the table Pressure is applied at a point above the knee for two reasons (1) To avoid joint strain of the internal lateral ligaments and (2) because the position of the examiner in relation to the patient permits sufficient leverage for strength test

NOTE

All muscles of the adductor group except the gracilis tend to externally rotate the thigh The gracilis tends to internally rotate the thigh if the knee is extended Anterior tilt of the pelvis or flexion of the hip (with backward rotation of pelvis on upper side) allows substitution of hip flexors Forward rotation of pelvis with extension of hip shows attempt to hold with lower fibers of gluteus maximus The adductors longus brevis and pectineus aid in hip flexion If the side lying position is maintained and the hip tends to flex as the thigh is adducted during the test it is not necessarily evidence of substitution—but merely evidence that these adductors are doing more than the rest of the adductors that assist in this movement There appears to be a considerable overlap in the group strength test for hip flexors and adductors In poliomyelitis patients weakness in one group usually coincides with weakness in the other

CONTRACTURE

Hip adduction deformity In standing the position is one of pelvic tilt with the pelvis high on the side of contracture With the pelvis elevated the foot on the same side must be held in equinus in order to touch the floor If the foot is placed flat on the floor the opposite leg must be either flexed or abducted to compensate for the apparent shortness on the adducted side

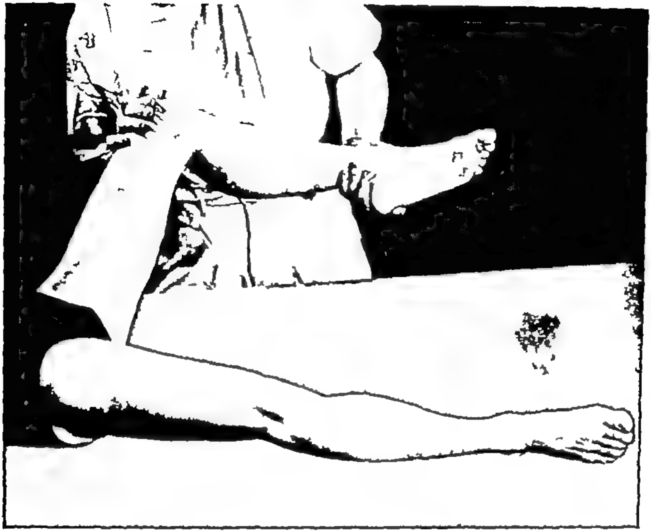


Fig 100 Sartorius

Patient

Supine

Fixation

None necessary on the part of the examiner The patient may hold on to the table

Test

External rotation abduction and flexion of the thigh with flexion of the knee

Pressure

Against the antero-lateral surface of the lower thigh in a downward inward direction and against the lower leg in the direction of knee extension The position of the examiner s hands acts to resist the hip external rotation action by pressure and counter pressure (in the same way as described under Hip External Rotator Test, p 170) The examiner must resist the multiple action test in a combined resistance movement

Weakness

Contributes to antero-medial instability at the knee

Contracture

Flexion, abduction and external rotation deformity of the hip with flexion of the knee

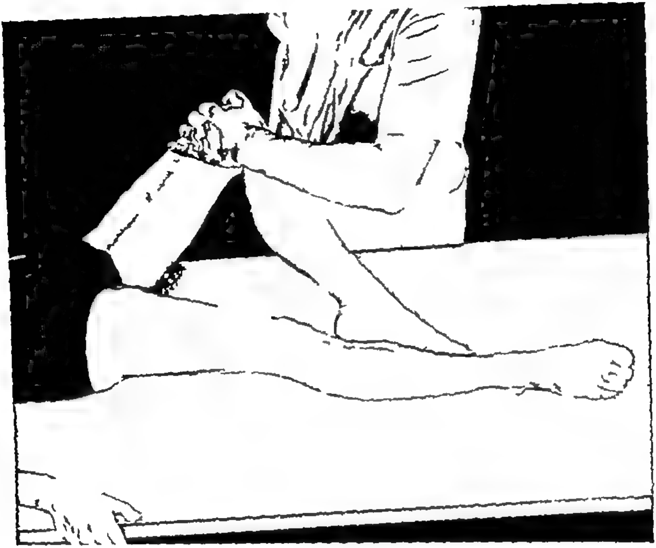


FIG 101 Error in testing sartorius

The position of the leg as illustrated resembles the sartorius test position in its flexion abduction and external rotation However the ability to hold this position is essentially a hip adductor function (as seen in this photograph) and requires little assistance from the sartorius A downward-outward pressure would be against the adductor line of pull It is necessary that the sartorius test be an active pull in the direction of abduction flexion and external rotation as described in the previous test

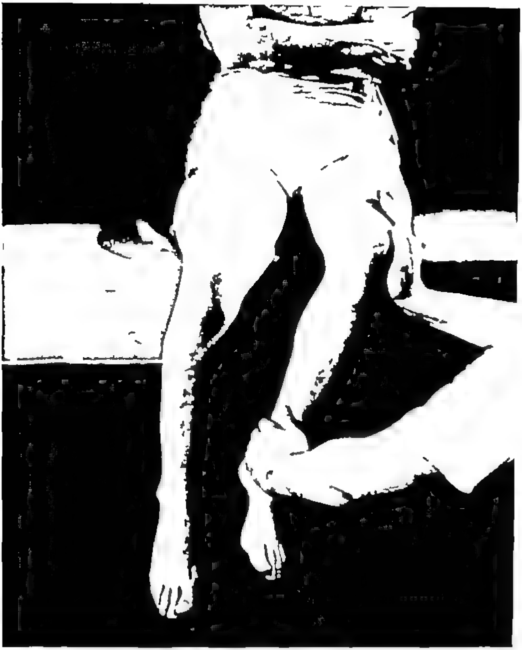


Fig 102 Hip external rotators

PATIENT

Sitting on the table with knees bent over the side of the table

FIXATION

The weight of the trunk stabilizes the patient during this test If the trunk is weak it is better to have the patient supine during the test Stabilization is also given in the form of counter-pressure (as described below under Pressure)

TEST

Outward rotation of the thigh, with the lower leg in position of completion of the inward arc of motion

PRESSURE

Counter pressure is applied by one hand of the examiner at the lateral side of the lower end of the thigh The other hand of the examiner applies pressure to the medial side of the lower leg above the ankle pushing the

lower leg outward in order to inwardly rotate the thigh.

WEAKNESS

Usually internal rotation and adduction of the thigh resulting in knock knee and external rotation of the lower leg in weight bearing Tendency toward increased anterior pelvic tilt with lumbar lordosis

CONTRACTURE

External rotation of the thigh usually in an abducted position

SHORTNESS

In the standing posture there results an external rotation of the femur abduction of the hip joint in relation to the pelvis (as evidenced by a low hip) or a rotation of the pelvis if the shortness exists unilaterally A tendency toward flattening of the lumbar spine by posterior tilting of the pelvis if the shortness exists bilaterally

Fig 103 Hip internal rotators

Patient

Sitting on the table with knees bent over the side of the table

Fixation

The weight of the trunk stabilizes the patient during this test If the trunk is weak it is better to have the patient supine during the test Stabilization is also given in the form of counter pressure (as described below under Pressure)

Test

Inward rotation of the thigh with the lower leg in position of completion of outward arc of motion

Pressure

Counter pressure is applied by one hand of the examiner at the medial side of the lower end of the thigh. The other hand of the examiner applies pressure to the lateral side of the lower leg above the ankle pushing the

lower leg inward in order to outwardly rotate the thigh

WEAKNESS

Results in external rotation of the lower extremity in standing and walking

CONTRACTURE

Internal rotation position of the hip with a tendency toward knock knee if the patient has been weight bearing

SHORTNESS

Inability to fully externally rotate the thigh
Inability to sit in a cross-legged position

NOTE

If the rotator test is done in a supine position the pelvis will tend to tilt if much pressure is applied but this is not a substitution movement Due to its attachments the tensor when contracting to maximum pulls forward on the pelvis as it inwardly rotates the leg

Fig 104. Tensor fascia femoris

Patient

Supine

Fixation

Quadriceps action is necessary to hold the knee extended. Usually no fixation is necessary by the examiner but if there is instability so that the patient has difficulty in maintaining the pelvis firm on the table then one hand of the examiner should support the pelvis anteriorly on the opposite side

Test

Abduction, flexion and internal rotation of the hip with the knee extended.

Pressure

Against the lower leg in a downward-inward direction.

WEAKNESS

In standing there is a thrust in the direction of a bow-leg position, and the extremity tends to rotate outward from the hip

SHORTNESS

The effect of a shortness of the tensor fascia lata in standing depends upon whether the tightness is bilateral or unilateral

Bilaterally

Anterior pelvic tilt and sometimes bilateral knock knee

Unilaterally

If the abductors and lateral fascia lata are tight along with the tensor fascia femoris muscle then there is an associated lateral pelvic tilt low on the side of tightness The knee on that side will tend toward knock-knee position If the tensor fascia femoris muscle is tight along with an anterior pelvic tilt there tends to be an internal rotation of the femur (as indicated by the position of the patella)

CONTRACTURE

Hip flexion and knock knee position

Fig 105 Gluteus Minimus

Patient

Side lying

Fixation

The examiner stabilizes the pelvis (See note below)

Test

Abduction of the hip in position neutral between flexion and extension, and neutral in regard to rotation

Pressure

Against the lower leg in a downward very slightly backward direction

NOTE

In tests of the gluteus minimus and medius or the abductors as a group the stabilization of the pelvis is necessary but often difficult It requires a strong fixation by many trunk muscles aided by stabilization on the part of the examiner The slight flexion of the hip and knee of the under leg aids in stabilizing the pelvis against anterior or posterior tilt The examiner's hand attempts to steady the pelvis to prevent the tendency to roll forward or backward the tendency to tilt anteriorly or posteriorly and to prevent if possible any unnecessary hiking or dropping of the pelvis laterally Any one of the six shifts in position of the pelvis may result primarily from trunk weakness or such shifts may indicate an attempt to substitute anterior or posterior hip joint muscles or lateral abdominals in the movement of leg abduction When the trunk muscles are strong it is not too difficult to maintain good stabilization of the pelvis But when trunk muscles are weak, the examiner may need the assistance of a second person to hold the pelvis steady

WEAKNESS

Lessens the strength of internal rotation and abduction of the hip joint

CONTRACTURE AND SHORTNESS

(See Gluteus Medius)

Fig 105 Gluteus Minimus

Patient

Side lying

Fixation

The examiner stabilizes the pelvis (See note below)

Test

Abduction of the hip in position neutral between flexion and extension and neutral in regard to rotation

Pressure

Against the lower leg in a downward very slightly backward direction.

NOTE

In tests of the gluteus minimus and medius or the abductors as a group the stabilization of the pelvis is necessary but often difficult It requires a strong fixation by many trunk muscles aided by stabilization on the part of the examiner The slight flexion of the hip and knee of the under leg aids in stabilizing the pelvis against anterior or posterior tilt The examiner's hand attempts to steady the pelvis to prevent the tendency to roll forward or backward the tendency to tilt anteriorly or posteriorly and to prevent if possible any unnecessary hiking or dropping of the pelvis laterally Any one of the six shifts in position of the pelvis may result primarily from trunk weakness or such shifts may indicate an attempt to substitute anterior or posterior hip joint muscles or lateral abdominals in the movement of leg abduction. When the trunk muscles are strong it is not too difficult to maintain good stabilization of the pelvis But when trunk muscles are weak the examiner may need the assistance of a second person to hold the pelvis steady

WEAKNESS

Lessens the strength of internal rotation and abduction of the hip joint

CONTRACTURE AND SHORTNESS

(See Gluteus Medius.)

Fig 106 Gluteus medius (posterior part)

Patient

Side lying

Fixation

The muscles of the trunk and fixation by the examiner stabilize the pelvis.

(See note under Gluteus Minimum Test p 177)

Test

Abduction of the hip with slight extension and slight external rotation

Pressure

Against the lower leg in a downward slightly forward direction The pressure is applied against the lower leg for the purpose of leverage

The posterior part of the gluteus medius muscle is the primary lateral stabilizer of the hip joint in standing. As such, a good deal of strength is necessary for normal function. For the purpose of a practical test to determine normal strength strong pressure is needed and can only be obtained by the examiner if the leverage is adequate.

In the adductor test pressure is kept above the knee joint because of the danger of injuring the internal lateral ligaments. There is relatively little danger of injuring the external lateral ligaments during the medius test because the knee joint is reinforced by a strong facial fixation. (This fascial pull is plainly visible in the accompanying photograph.)

The evidence of fascia lata fixation in this test need not be construed as a strong test of the tensor fascia femoris muscle. The fascia is connected with the muscles of the thigh and a strong pull of antero-lateral or postero-lateral hip muscles will usually be accompanied by strong fascial fixation.

WEAKNESS

With marked weakness there will be a glutueus medius limp in walking. This consists of displacement of the body weight laterally toward the weak hip in such a way that the hip joint is thrust in the position of hip abduction in relation to the pelvis. With slight weakness of the medius there will be the postural deviation in which the pelvis is high on the side of weakness (that is there will be an adduction of the hip in relation to the pelvis) and an associated internal rotation of the femur. As a result of such unilateral pelvic tilt, the spine deviates with convexity toward the opposite (low) side. In other words a slight weakness of the right gluteus medius gives rise to a *left* C-curve. (See fig. 100.)

CONTRACTURE

An abduction deformity which in standing may be seen as a low pelvis on the side of contracture along with some actual abduction of the leg.

SHORTNESS

Abduction of the leg if the pelvis is level, or low pelvis (on side of shortness) if the legs are both in position of midline adduction in relation to trunk. Tightness of the gluteus medius and minimus will be similar except that the medius will tend to draw the leg into *external rotation* while the *minimus* will draw it into internal rotation.

Fig 107 Gluteus maximus

PATIENT

Prone

FIXATION

Posteriorly the back muscles and laterally, the lateral abdominal muscles fix the pelvis to the trunk

TEST

Hip extension with knee flexed 90 degrees or more (The more the knee is flexed the less the hip will extend due to restricting tension of the rectus femoris anteriorly)

PRESSURE

Against the lower part of the posterior thigh in the direction of hip flexion (that is downward toward the table)

NOTE

The anatomical action of the gluteus maximus is to extend the thigh with slight external rotation. By virtue of the fact that the upper fibers tend to abduct and the lowest fibers tend to adduct, the muscle is able to extend in a position neutral between abduction and adduction. During the test, the thigh will tend to deviate laterally or medially if imbalance exists between the abductor and adductor stabilizers.

The action of the gluteus maximus in hip extension without assistance from the hamstrings is well illustrated in above-knee amputation cases in which the hamstrings have not been re-inserted on the thigh.

Indirect fixation muscles enter into action in such tests as the gluteus maximus. In a test of the right gluteus maximus in the prone position, the left quadriceps and hip flexors offer much indirect fixation. One need only try the test of the gluteus maximus without the fixation of the other leg to realize this important factor. If the left quadriceps fixation is ruled out (along with the weight of the lower leg) during a test of the right gluteus maximus, much less than the usual amount of pressure will be necessary to break the pull of a normal muscle.

To make the difference even more pronounced, the test may be tried with the left leg hanging over the side of the table, thus removing the weight as well as the pull of the quadriceps and hip flexors during the test of the right maximus. One should bear in mind such factors as illustrated by these examples in testing muscles on amputees. In a right above knee amputee it is often advisable to leave the prosthesis on the right leg, for example, while testing the left leg in order that the weight of the prosthesis and the action of the hip muscles may give fixation.

The insertion of the gluteus maximus into the fascia and ilio-tibial band (in addition to its femoral insertion) is an important factor in the function of the maximus. The bony insertion is at the proximal end of the femur and provides only short leverage. By its insertion into the ilio-tibial band, the maximus is provided with a leverage that extends to the tibial insertion of the ilio-tibial band.

The fascial connection acts as a strong force in the combined action of hip and knee extension, as in stair climbing or rising from a knee bent position.

WEAKNESS

Bilateral marked weakness of the gluteus maximus makes walking extremely difficult and necessitates the aid of crutches. With marked weakness the individual bears weight on the extremity in a position of postero-lateral displacement of the trunk over the femur to the point that restriction of further motion is obtained by the anterior hip joint ligaments.

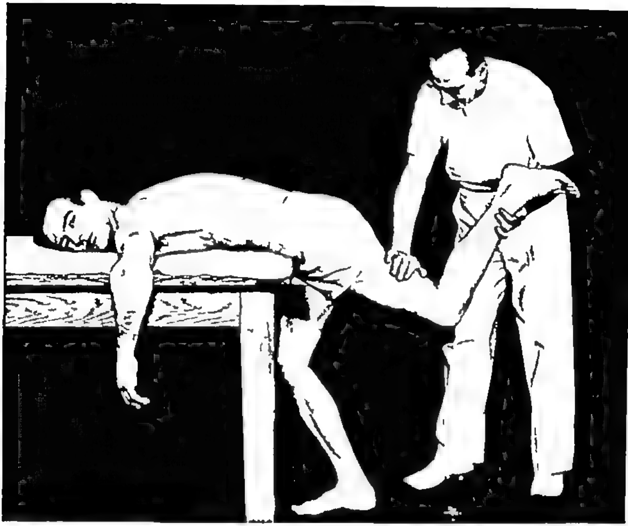


FIG 108 Modified gluteus maximus test

When back extensor muscles are weak or hip flexor muscles tight it is often necessary to modify the gluteus maximus test The accompanying illustration shows the modified test

PATIENT

Trunk prone on the table the legs hanging down over the end of the table

FIXATION

The patient usually needs to hold onto the table when pressure is applied

TEST

Extension of the hip (1) with the knee passively flexed by examiner as illustrated or (2) with the knee extended (permitting hamstring assistance)

PRESSURE

This test presents a rather difficult problem in regard to application of pressure If the maximus is to be isolated as much as possible from the hamstrings it requires that knee flexion be maintained by the examiner (Otherwise the hamstrings will unavoidably act in maintaining the anti-gravity knee flexion) Trying to maintain knee flexion passively and apply pressure to the thigh makes it difficult to obtain accurate test results

If this test is used because of hip flexor tightness it may be impractical to flex the knee and increase the rectus femoris tension over the hip joint The authors consider it advisable to use the modification [(2) under Test above] but have illustrated the first modification in order to bring out the disadvantages involved

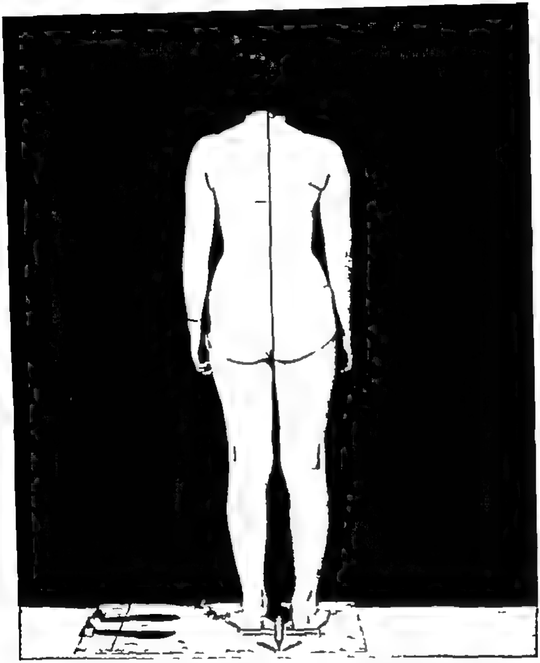


FIG 109 Postural deviation associated with hip abductor weakness

Slight hip abductor weakness unilaterally is frequently found in association with lateral pelvic tilt The abductors are weak on the slightly elevated side of the pelvis The accompanying illustration has been chosen because it represents the mild degree of postural deviation that is frequently seen

The spine deviates slightly to the left and the right shoulder drops to compensate for the deviation of the pelvis and spine The beginning weakness in the abductors as seen in non paralytic individuals is usually a strain weakness from postural or occupational causes But once the weakness is established it further contributes to the faulty mechanics

CHAPTER V

TRUNK MUSCLES

Anterior and Lateral Trunk Muscles

Testing of abdominal muscles presents certain problems which differ in kind or degree from those met in testing other muscles. The factors which give rise to these problems relate to muscle action, fixation, and leverage.

Since the large oblique muscles cover such an extensive area and have such a wide range of attachments, various parts of the muscles have different functions. Different sections of these muscles are drawn into action to varying degrees in a trunk movement at any given point in an arc of motion. Almost any test position is held by several abdominal muscles pulling with all or only part of their fibers. Most test movements are performed by several abdominal muscles or muscle segments which act together or in sequence as the part moves through the arc of motion.

The anatomical arrangement of the abdominal muscles is responsible for unusual problems in fixation. Many of the fibers originate or insert in the fascia of the midline. These fibers depend for fixation upon muscle fibers which, in most cases, arise from the opposite side of the midline fascia.

Because the midline fascia is not rigid, it readily moves toward a strong muscle which is pulling against a weak fixation muscle. Fascial deviation is indicated by a deviation of the umbilicus and occurs during test movements whenever abdominal muscle imbalance exists.

Abdominal muscles are graded by anti-gravity test movement or test position except when marked weakness necessitates modification of test procedure. The 100% grade is determined by the ability of the tested muscles to move or support the part against gravity. It should be noted that no pressure by the examiner is needed to determine differences in grades above 50%. The weight of the parts to be moved or held and the lengths of the levers involved combine with the help of gravity to demand maximal exertion from the tested muscles.

One further factor which may complicate the matter of testing abdominal muscles is the very prevalent misconception of their rôle in trunk and leg raising. The action of leg raising which is frequently credited to the abdominal muscles is actually the function of the hip flexors. In fact, it is anatomically impossible for the abdominal muscles to perform this action because they have no attachment on the femur. For the same anatomical reason, trunk raising, even though it be initiated by abdominal muscles, must be completed by the hip flexors.

For most purposes, it is sufficient to grade abdominal muscles on the basis of functional group-action tests. Strength tests are necessarily of such nature because of the interdependence of abdominal muscles in producing trunk movements.

However, in relation to pre-surgical examination when fascial transplants are contemplated, it is necessary to analyze carefully the segmental imbalance of the muscles. In poliomyelitis cases there may be spotty segmental imbalance. In cord injury cases there will be loss of muscle innervation in relation to the level of the lesion. The rectus and transversus abdominis tend to lose innervation on a transverse segmental basis; the obliques, in an obliquely segmental manner.

Location and Function of Abdominal Muscles

ORIGIN, INSERTION, AND ACTION

The entire abdomen is covered with fascia. In the midline of the abdomen a wide band of tendinous fascia forms the aponeuroses for attachment of various muscles. These aponeuroses join at the midline to form the linea alba.

Four large muscles make up the anterior abdominal wall. Most superficial is the exter

nal oblique (right and left portions), with the fibers extending downward and medialward. Beneath it lies the internal oblique (right and left portions) with fibers extending essentially upward and medialward The aponeurosis of the internal oblique separates into two layers to furnish a sheath covering over the rectus abdominis. The rectus abdominis extends vertically from the pubis to the sternum and angle of the ribs Innermost of the abdominal muscles is the transversus abdominis the fibers of which horizontally encircle the abdomen.

As was stated above various parts of the oblique muscles have different functions In this text these muscles are being divided arbitrarily into three parts for convenience in describing the various actions

Figure 110 shows the anterior view of the external and internal obliques divided into parts a b and c for the external and a' b and c' for the internal

External Oblique (See figs. 110 111 and 112)

Part a

Origin 5th and 6th ribs (Interdigitating with serratus anterior and fascia of pectoralis major)

Insertion Aponeurosis

Line of fibers Medialward and downward.

Action This portion has relatively short fibers without sufficient leverage to influence materially rotation of the thorax on the pelvis except insofar as it furnishes completion of the pull for part of the b fibers of the internal oblique (described below) Part a of the external oblique acts mainly to compress the portion of the rib cage to which it is attached and assists in initiation of flexion of the thorax on the pelvis

Part b

Origin 7th 8th and 9th ribs. (Interdigitating with serratus anterior)

Insertion Aponeurosis.

Line of fibers Downward and medialward.

Action This portion depends for its fixation on part b of the internal oblique and acting with it strongly rotates the thorax forward on the pelvis The combined action of right and left muscle portions assists in flexion of the thorax on the pelvis

Part c

Origin 10th 11th, and 12th ribs and closely allied with the fascia of the latissimus dorsi interdigitating with part of that muscle

Insertion Anterior half of the iliac crest (See fig 112)

Line of fibers Downward and slightly medialward

Action With attachments from bone to bone this portion can act independently of any fixation from other abdominal muscles For this reason it exceeds parts (a) and (b) in ability to rotate the thorax forward on the pelvis In addition to the power of rotation it has a strong lateral pull which the other parts of the muscle do not possess When the left and right portions combine in action they carry the thorax forward over the pelvis and help to roll or tilt the pelvis back flattening the lumbar spine The action of this portion is comparable to the action of the sternocleidomastoid on the head and thorax

Internal Oblique (See figs 110 111 and 113)

Part a'

Origin Lateral lip of iliac crest and lumbodorsal fascia

Insertion The inferior borders of the 10th 11th and 12th ribs and the cartilages of the 7th 8th and 9th ribs

Line of fibers Upward and medialward (anteriorly) more vertical than b portion

Action This portion with attachment from bone to bone like c" portion of external oblique does not need fixation from other abdominal muscles and is there-

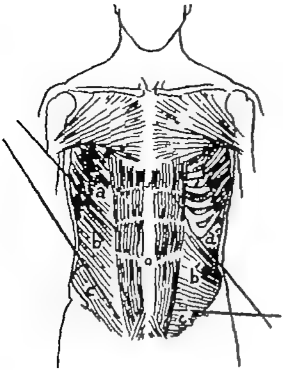


FIG 110 Anterior view showing division of right external oblique into a b and c parts and left internal into a b and c parts

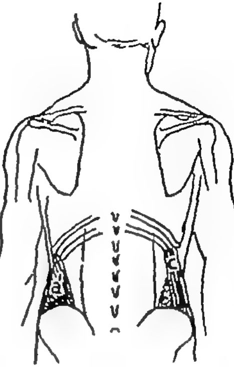


FIG 111 Posterior view showing posterior fibers of left internal oblique a and right external oblique c

fore a strong factor in rotation of the thorax backward on the pelvis When right and left sides act together they displace the thorax backward on the pelvis causing kyphotic position of the dorsal spine

Part b

Origin Anterior third of iliac crest

Insertion Aponeurosis and linea alba

Line of fibers Upward and medialward

Action This portion receives its fixation from b portion of the external oblique (and acts as described above under external b portion)

Part c

Origin From the inguinal ligament and a short attachment on the iliac crest near the anterior superior iliac spine

Insertion With the transversus abdominis into the crest of the pubis medial part of the pectineal line and the linea alba

Line of fibers Transverse

Action This portion of the internal oblique receives its fixation from the same portion of the opposite internal and acts with the transversus to compress the low abdominal wall Being attached from one side of the pelvis to the other it is unable to enter into the flexion or rotation of the trunk

RECTUS ABDOMINIS (See fig 114)

Origin Crest of the pubis

Insertion Cartilages of the 5th 6th and 7th ribs and the xiphoid process of the sternum

Line of fibers Vertical

Action The distance between the sternum and the pubis is shortened by either

FIG 112 Lateral view of left external oblique showing a b and c portions

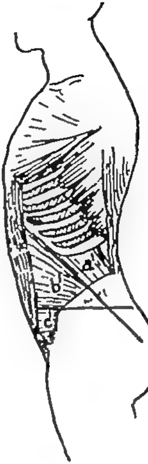


FIG 113 Lateral view of left internal oblique showing a b and c portions

(1) forward flexion of the thorax on the pelvis or (2) flexion of the pelvis on the thorax (that is backward pelvic tilt)

TRANSVERSUS ABDOMINIS (See figs 114 and 115)

Origin Inguinal ligament anterior 2/3 of iliac crest inner surface of cartilages of 6 lower ribs interdigitations with diaphragm and lumbodorsal fascia

Insertion Crest of pubis and pectineal line and into aponeurosis

Line of fibers Transverse

Action To compress the abdominal viscera and in expiration to help decrease the angle of the ribs This muscle has no lateral flexion action but in lateral trunk flexion it acts to compress the viscera and thereby permit a better pull by the other muscles In the standing position weakness permits an anterior bulging of the abdominal wall (See fig 120)

LATERAL ABDOMINAL MUSCLES

Part a External Oblique
Part a Internal Oblique
Quadratus Lumborum
Latissimus Dorsi

TRUNK RAISING FORWARD

ANALYSIS OF THE MOVEMENT By trunk raising forward is meant the movement of coming from a supine to a sitting position The way the movement is accomplished depends on the action of the abdominal and hip flexor

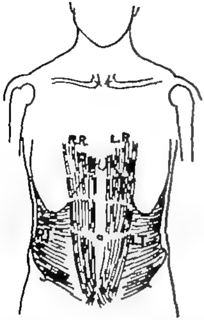


Fig 114 Anterior view showing left and right portions (L R. and R R.) of rectus abdominis and left and right portions (L T and R T) of transversus abdominis

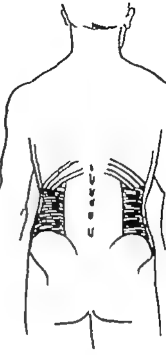


Fig 115 Posterior view showing posterior fibers of transversus abdominis

muscles Three main differences occur according to the strength of these muscles

(1) When the abdominal and hip flexor muscles are normal an individual can come to the sitting position by first flexing the trunk (that is the thorax is flexed on the pelvis) then flexing the pelvis on the thighs (See figs 116 a and b) (Flexion of the trunk refers only to the approximation of the sternum and pubis and is purely anterior abdominal action Flexion of the pelvis on the thighs is purely hip flexor action)

The above movement is obtained by 'folding' to a sitting position raising first the head then the shoulders then the entire trunk. Flexion of the trunk is completed when the region of the 7th cervical vertebra is about eight inches from the table (The distance varies with the degree of back flexibility At this point in the arc of motion flexion of the pelvis on the thigh is initiated by the hip flexors which then complete the action of trunk raising

By the foregoing description it is evident that trunk raising done this way is really two distinct movements As described in the following paragraph however it is only one movement.

(2) When abdominal muscles are weak and hip flexor muscles strong an individual can come to a sitting position by hyper-extending the trunk and flexing the pelvis on the thigh The hyperextension of the trunk is accomplished by low back erector spinae and hip flexor action Flexion of the pelvis on the thigh is as stated above purely hip flexor action (See figs 119 a and b)

Trunk raising done in this way should not be considered either an exercise or a test movement As an exercise its effect is to weaken the abdominal muscles because they are in a position of stretch It is useless as a test because it gives no indication of the degree of abdominal strength

(3) When abdominal muscles are strong and hip flexors are weak an individual cannot come

to a sitting position. Action begins by first flexing the trunk but the flexion of the pelvis on the thighs is not accomplished in the absence of good hip flexor strength

In fact when hip flexors are weak lack of adequate fixation for the abdominal muscles prevents complete range of trunk flexion The imbalance in strength permits the abdominal muscle pull to tilt the pelvis too far posteriorly As a result these muscles reach maximal shortness without getting a maximal lift on the trunk Because of this mechanical disadvantage the muscles support less weight than they could under normal conditions For this reason it is recommended that in addition to raising the trunk through this limited range of motion the muscles should be expected to hold against moderate pressure exerted against the head (if neck flexor strength is good) or against the sternum

Analysis of the Muscle Action As illustrated by figure 117 flexion of the thorax on the pelvis combines the action of the rectus abdominis and the internal oblique (aided by the upper fibers of the external oblique which furnish fixation for the opposite fibers of the internal oblique) If both the rectus abdominis and the internal obliques are strong the pubis will be pulled toward the sternum as the thorax is raised and the lumbar spine will flatten on the table This occurs even though no effort is made to "roll the pelvis" provided there is no marked contracture of the erector spinae and provided no support is exerted downward on the legs to permit an initial fixation by hip flexors (This point is discussed in detail below)

The thorax can be raised to almost maximum trunk flexion by the pull of the internal oblique even though the rectus is quite weak The difference that will be noted however is that the pelvis will not be pulled into a position of backward tilt as strongly as when the rectus is normal When the movement of flexion of the pelvis on the thighs is initiated as the patient continues to come toward the sitting position the pelvis will be seen to tilt rather suddenly away from the fixation of the weak rectus toward the pull of the stronger hip flexors (When the rectus is weak the line of fixation is only from (1) to (3) instead of from both (1) to (3) and (1) to (2) as seen in figure 117)

It is necessary to watch the pelvis closely to see this action because the dorsal (and cervical) spine maintains its flexion and the patient apparently "folds" to sitting position If the rectus abdominis is contracting strongly it usually shows as a wide band down the midline of the abdomen

Just before the action of flexion of the pelvis on the thighs is initiated to bring the patient to a complete sitting position the postero-lateral fibers of the external oblique come into strong action.

The action of these muscles in trunk flexion is most obvious when there is a difference in their strength such as seen frequently in cases of scoliosis The twisting of the thorax on the pelvis which results from this imbalance occurs just before trunk flexion is completed

In figure 117 the buttocks represent the fixed part toward which the sternum moves in trunk flexion In figure 118 the legs represent the fixed part toward which the trunk moves when flexed on the thighs

As a patient folds toward a sitting position, an increasing amount of the weight of the trunk is raised from the table and must be supported by the abdominal muscles The weight supported reaches a maximum at just about the time that trunk flexion is completed At this point when the hip flexors come into action fixation by the weight of both legs is necessary If the weight of the legs is not enough to counter-balance the weight of the trunk the examiner must provide additional fixation by holding the legs firmly down on the table

Raising of the legs during a trunk raising test should not be permitted It introduces factors of leverage fixation and muscle substitution which interfere with the validity of the test The *tendency* to raise the legs which is primarily a matter of counterbalancing the trunk and leg weight is increased when abdominal weakness is moderate or severe

The examiner *must not* provide fixation for the legs before the moment at which the point of

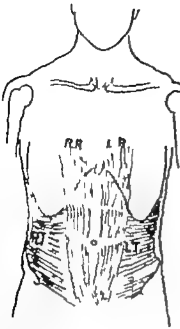


Fig 114 Anterior view showing left and right portions (L. R. and R R) of rectus abdominis and left and right portions (L T and R T) of transversus abdominis

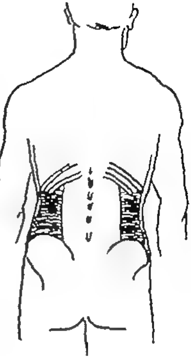


Fig 115 Posterior view showing posterior fibers of transversus abdominis

muscles Three main differences occur according to the strength of these muscles

(1) When the abdominal and hip flexor muscles are normal an individual can come to the sitting position by first flexing the trunk (that is the thorax is flexed on the pelvis) then flexing the pelvis on the thighs (See figs 118 a and b) (Flexion of the trunk refers only to the approximation of the sternum and pubis and is purely anterior abdominal action Flexion of the pelvis on the thighs is purely hip flexor action)

The above movement is obtained by "folding" to a sitting position, raising first the head, then the shoulders then the entire trunk. Flexion of the trunk is completed when the region of the 7th cervical vertebra is about eight inches from the table (The distance varies with the degree of back flexibility) At this point in the arc of motion flexion of the pelvis on the thigh is initiated by the hip flexors, which then complete the action of trunk raising.

By the foregoing description it is evident that trunk raising done this way is really two distinct movements As described in the following paragraph however it is only one movement.

(2) When abdominal muscles are weak and hip flexor muscles strong, an individual can come to a sitting position by hyper-extending the trunk and flexing the pelvis on the thigh. The hyperextension of the trunk is accomplished by low back erector spinae and hip flexor action. Flexion of the pelvis on the thigh is as stated above purely hip flexor action. (See figs. 119 a and b)

Trunk raising done in this way should not be considered either an exercise or a test movement. As an exercise its effect is to weaken the abdominal muscles because they are in a position of stretch It is useless as a test because it gives no indication of the degree of abdominal strength.

(3) When abdominal muscles are strong and hip flexors are weak, an individual cannot come

to a sitting position. Action begins by first flexing the trunk but the flexion of the pelvis on the thighs is not accomplished in the absence of good hip flexor strength

In fact when hip flexors are weak lack of adequate fixation for the abdominal muscles prevents complete range of trunk flexion The imbalance in strength permits the abdominal muscle pull to tilt the pelvis too far posteriorly As a result these muscles reach maximal shortness without getting a maximal lift on the trunk Because of this mechanical disadvantage the muscles support less weight than they could under normal conditions For this reason it is recommended that in addition to raising the trunk through this limited range of motion the muscles should be expected to hold against moderate pressure exerted against the head (if neck flexor strength is good) or against the sternum

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It is necessary to watch the pelvis closely to see this action because the dorsal (and cervical) spine maintains its flexion and the patient apparently "folds" to sitting position. If the rectus abdominis is contracting strongly it usually shows as a wide band down the midline of the abdomen.

Just before the action of flexion of the pelvis on the thighs is initiated to bring the patient to a complete sitting position the posterolateral fibers of the external oblique come into strong action

The action of these muscles in trunk flexion is most obvious when there is a difference in their strength such as seen frequently in cases of scoliosis The twisting of the thorax on the pelvis which results from this imbalance occurs just before trunk flexion is completed

In figure 117 the buttocks represent the fixed part toward which the sternum moves in trunk flexion In figure 118 the legs represent the fixed part toward which the trunk moves when flexed on the thighs

As a patient folds toward a sitting position an increasing amount of the weight of the trunk is raised from the table and must be supported by the abdominal muscles The weight supported reaches a maximum at just about the time that trunk flexion is completed *At this point* when the hip flexors come into action fixation by the weight of both legs is necessary If the weight of the legs is not enough to counter-balance the weight of the trunk the examiner must provide additional fixation by holding the legs firmly down on the table

Raising of the legs during a trunk *raising* test should not be permitted It introduces factors of leverage fixation and muscle substitution which interfere with the validity of the test The tendency to raise the legs which is primarily a matter of counterbalancing the trunk and leg weight is increased when abdominal weakness is moderate or severe

The examiner must not provide fixation for the legs before the moment at which the point of

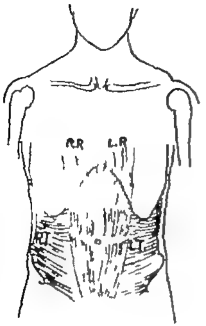
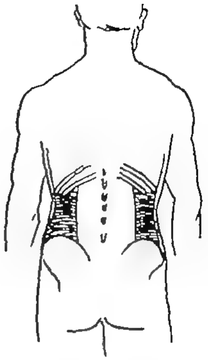


FIG 114 Anterior view showing left and right portions (L. R. and R. R.) of rectus abdominis and left and right portions (L. T and R. T) of transversus abdominis



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Trunk raising done in this way should not be considered either an exercise or a test movement. As an exercise its effect is to weaken the abdominal muscles because they are in a position of stretch It is useless as a test because it gives no indication of the degree of abdominal strength.

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Raising of the legs during a trunk raising test should not be permitted It introduces factors of leverage fixation and muscle substitution which interfere with the validity of the test The tendency to raise the legs which is primarily a matter of counterbalancing the trunk and leg weight is increased when abdominal weakness is moderate or severe

The examiner must not provide fixation for the legs before the moment at which the point of

a

b

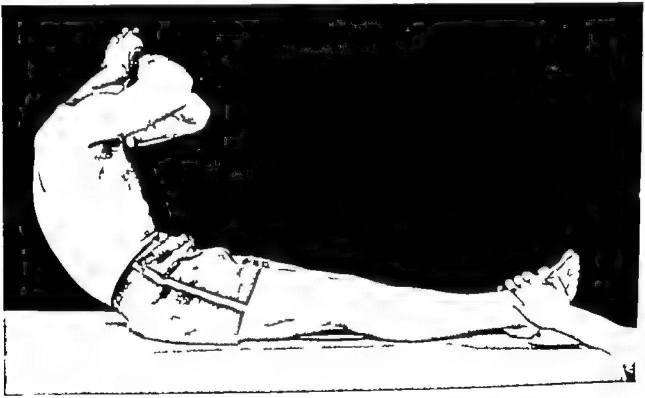


FIG 116

(a) With normal anterior abdominal muscles the patient can roll his pelvis to flatten his lumbar spine on the table Then with legs unsupported he can initiate and complete trunk flexion This picture shows the arms in position for the 100% trunk raising test

(b) When flexion of the pelvis on the thighs is initiated by the hip flexors the examiner usually must help to provide fixation by holding the legs firmly down on the table The picture illustrates the second phase of the 100% trunk-raising test

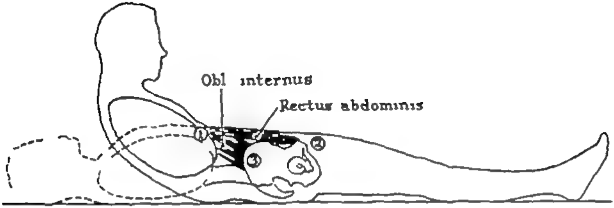


Fig 117 Trunk flexion is accomplished chiefly by the rectus abdominis and the internal oblique

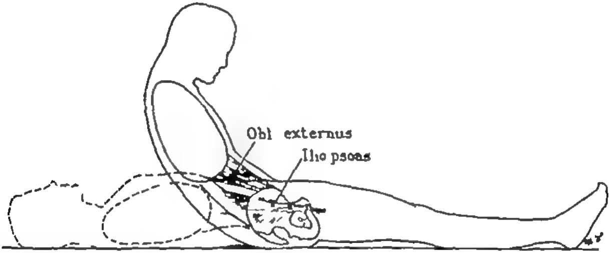
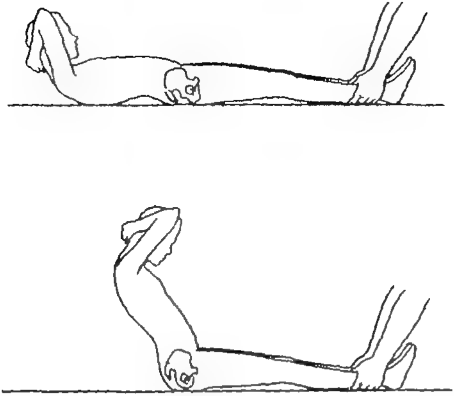


Fig 118

Just before flexion of the pelvis on the thighs is initiated the external oblique comes into strong action pulling in line with the ilio-psoas and other hip flexors which produce flexion of the pelvis on the thighs

a



b

Fig 119 (a) and (b)

With weak anterior abdominal muscles a patient can come to a sitting position, but the movement is accomplished by hip flexor action The hyperextended trunk is brought forward as the pelvis is flexed on the thighs. The patient is unable to initiate this movement slowly unless the legs are supported at the beginning of the movement

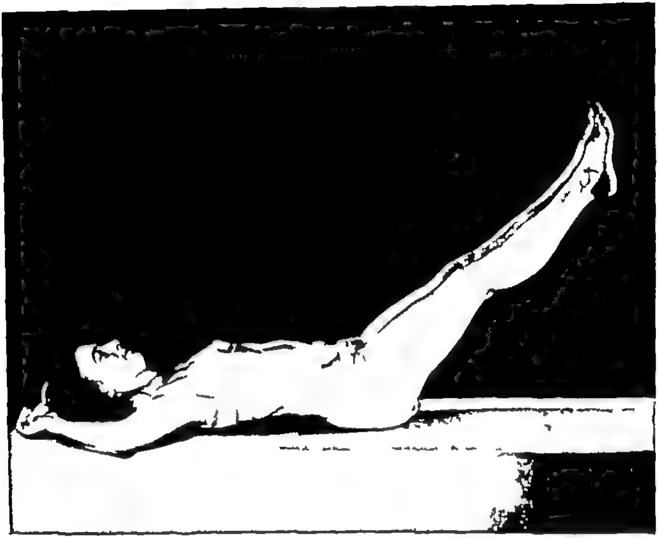
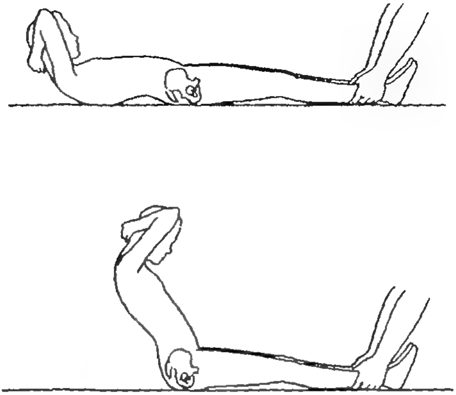


FIG 120 With weak anterior abdominal muscles the back will arch from the table as the weight of the legs is lifted

a

b



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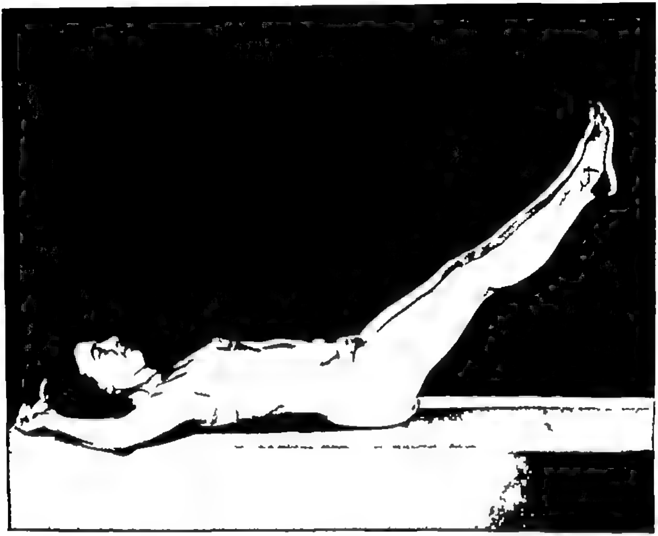


FIG 120 With weak anterior abdominal muscles the back will arch from the table as the weight of the legs is lifted

fixation should be changed from the pelvis to the lower extremities If pressure is exerted too soon it will enable hip flexor action to obscure or replace abdominal muscle action in a trunk raising test

Emphasis should be placed upon making trunk flexion a smooth controlled, "folding" action In this way validity of the test can be assured

A factor which must be considered in evaluation of abdominal muscle strength is the flexibility of the patient's back Strong abdominal muscles will be unable to flex the trunk through a normal range of motion, or hold in a specified test position, if the back is unusually tight To avoid inaccuracy the examiner should passively flex the patient's trunk to determine back flexibility before giving abdominal tests

DOUBLE LEG RAISING

ANALYSIS OF THE MOVEMENT Leg raising from a supine position is a hip flexor action (assisted by quadriceps if knees are maintained in extension) The movement may be done in one of two ways and may or may not be combined with abdominal action, depending on the position of the pelvis

(1) If the back is allowed to hyperextend as the legs are raised the abdominal muscles will be put on a stretch and the movement will be accomplished by the hip flexors (See fig 120)

(2) However if the patient is asked to flex the pelvis on the trunk (that is roll the pelvis to flatten the lumbar spine on the table) and hold it there as the legs are raised the abdominal muscles must act to hold the pelvis in that position The legs as they are lifted exert a strong pull downward on the pelvis The work of the abdominals is to approximate the pubis toward the sternum and maintain an upward pull on the pelvis in opposition to the downward pull of the legs (See fig 121)

When the abdominal muscles are weak and hip flexors are strong the back cannot be held flat as the legs are raised Consequently attention must be focused on the position of the pelvis during the leg raising not on the leg raising movement itself

Anatomical facts do not justify the prevalent use of double leg raising as an abdominal exercise The abdominal muscles do not raise the legs If they are strong enough to stabilize the pelvis while the legs are raised, they do not need this exercise If they are too weak to stabilize the pelvis this movement is too strenuous and causes undue abdominal muscle strain

The fundamental principle that exercise should be adapted to individual needs is much abused in the selection of so-called therapeutic and conditioning exercises Double-leg raising is an exercise which emphasizes the importance of this principle even in relation to so-called normal individuals For example anyone who has a lordosis or anterior pelvic tilt, usually has weak abdominal muscles and over-developed hip flexors The more severe the lordosis the greater is the imbalance Double-leg raising will increase the muscle imbalance and the degree of lordosis and is definitely contra indicated

Though leg raising is not suitable as an exercise it is used to advantage in muscle testing Abdominal muscle tests based upon leg raising and upon resistive arm and leg movements will be discussed in a later section of this chapter

ANALYSIS OF THE MUSCLES Figure 122 illustrates the direction of abdominal muscle pull during double leg raising by hip flexors The rectus abdominis and the external obliques (with necessary fixation by the internal obliques) flatten the lumbar spine on the table by pulling the pelvis into a position of backward tilt and holding it there

The test which measures abdominal strength in the action described above is frequently referred to as the leg raising test for "lower" abdominal muscles The word lower does not designate the location of the abdominal muscles being tested but indicates that the primary emphasis is upon movement of the pelvis in relation to the trunk

Similarly the trunk raising test is often referred to as a test of the "upper" abdominal muscles because primary emphasis is upon movement of the thorax in relation to the trunk.

In a correct movement for a lower abdominal muscle test the patient clasps his hands under his head and is not permitted to flex his dorsal spine Under these conditions he will be able to keep his back flat against the table if the pull of both the rectus and the postero-lateral external oblique muscles is strong Patients with back pain may be permitted to fold their arms on their chests during the test movement This makes the test a little less strenuous but does not materially affect the performance of it

A patient with very strong rectus abdominis and weak lateral oblique muscles may hold his back down during a leg raising test if he is permitted to place his arms on the table and flex his entire back by depressing his chest strongly This should not be confused with the correct test performance as described above

If the external oblique muscles are strong and the rectus abdominis weak the patient can flatten his lumbar spine by "rolling his pelvis but cannot maintain the flat position of the spine if the legs are raised from the table

TRUNK RAISING SIDEWAYS

Analysis of the Movement The test movement is done in side lying position with upper trunk pelvis and legs in straight line and abdomen retracted The top arm is extended down along the side (with the fingers closed so patient will not hold on to pelvis and attempt to pull himself up with his arm) The under arm is forward across the chest with the hand holding the upper shoulder (to rule out assistance by pushing up with the elbow)

The examiner then holds the patient's legs firmly on the table and asks him to lift his under shoulder from the table by raising his trunk Three different actions may occur

(1) When the leg abductors and the lateral abdominal muscles are normal the patient will flex laterally and raise himself easily from the table (as shown by fig 123)

(2) If the leg abductors are weak and the lateral abdominal muscles strong the pelvis is pulled upward as the rib cage is pulled toward it There may be complete approximation of the lateral iliac crest and rib cage yet the patient will scarcely raise his shoulders from the table Sometimes it is possible in such a case if the patient is not too large to exert enough downward pull on the pelvis laterally to stabilize it and the strong lateral abdominals may then perform the normal test movement If the examiner shoves the pelvis upward as he holds the legs firmly down on the table he may produce a picture of apparent weakness that resembles this type of imbalance even though muscles are normal

(3) If the lateral abdominals are weak and the leg abductors are very strong substitution by a combination of muscles may enable a patient to raise the trunk from the table laterally In this case strong anterior and posterior trunk muscles hold the trunk rigid while the hip abductor muscles pull the trunk into a position of abduction on the thigh The rib cage and iliac crest will not be approximated as they are when the lateral abdominals are strong By decreasing the pressure with which he is providing fixation for the leg abductors the examiner can make it necessary for the lateral abdominals to attempt initiation of the movement

Analysis of the Muscle Action Test of the lateral trunk muscles may reveal an imbalance in the oblique muscles In side raising if the legs and the pelvis are held steady that is not permitted to twist forward or backward from the direct side lying position the thorax is frequently rotated forward or backward as the trunk is laterally flexed. A forward twist denotes a stronger pull by the external oblique while a backward twist denotes a stronger pull by the internal oblique If the back hyperextends as the patient raises himself the quadratus lumborum and the latissimus dorsi are pulling strongly and the direct anterior abdominal fixation is not sufficient to maintain the trunk in straight line with the pelvis

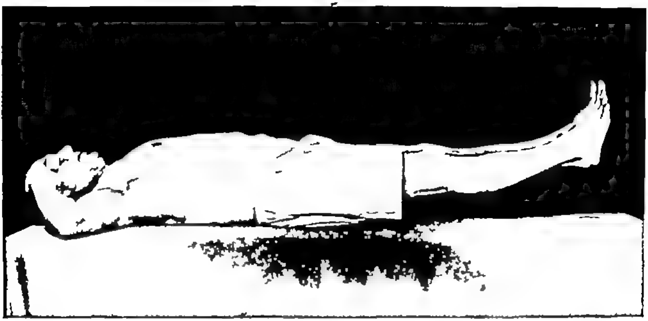


FIG 121

If the hip flexors (and quadriceps) are strong enough to raise the extended legs from the table an individual with normal anterior abdominal muscles can flatten the low back on the table and hold it there while initiating leg raising

The leg raising movement demands maximum strength in the initial stage As a result if a person with weak abdominal muscles were to attempt to hold the position of slight hip flexion which is illustrated it would cause maximal strain of his abdominal muscles (The weakness of the abdominal muscles would be made obvious to an examiner by marked arching of the low back)

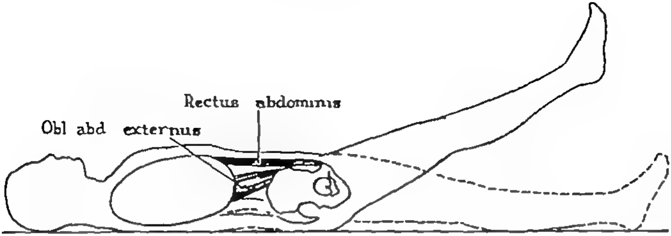


FIG 122 The back is held flat on the table during double leg raising and lowering chiefly by the action of the rectus abdominis and the external oblique muscles

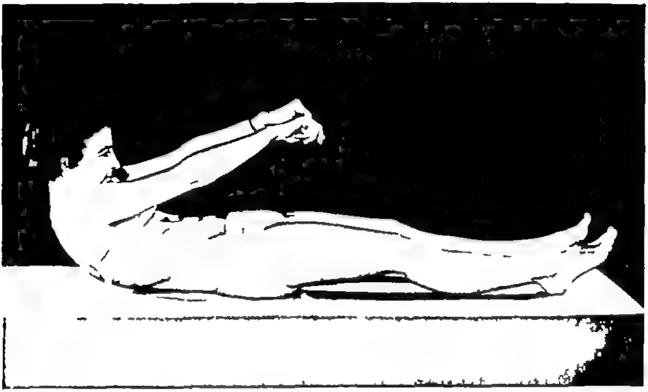


FIG 125 Arm position for the 60% trunk raising test

The movement is completed as in figure 116 b except that the arms maintain their position of forward flexion

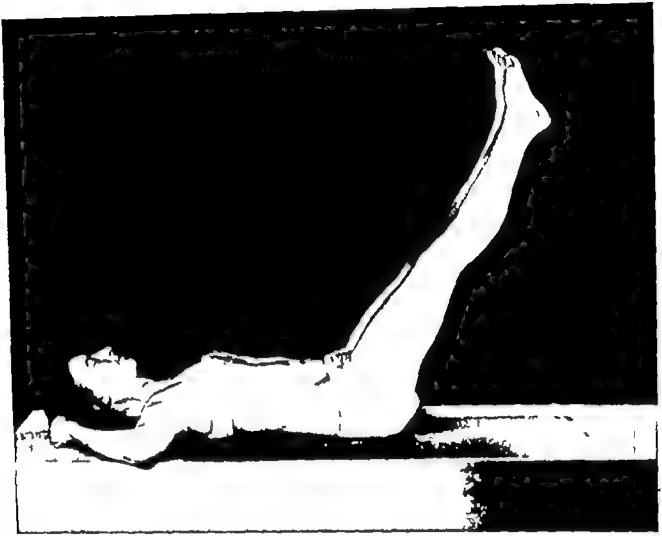


Fig 126 60% leg raising test

Back is held flat as legs are maintained at an angle of about 60° from the table Note pull of rectus abdominis and (right) external oblique muscles

Fig 127 100% oblique trunk raising test

Testing strength of the right external and the left internal oblique muscles in a diagonal pull. The thorax is flexed on the pelvis and rotated forward on the right (that is, the side of the external oblique) The legs must be stabilized by an assistant. The muscles drawn on the skin are the right external and the left internal oblique

TRUNK RAISING OBLIQUELY FORWARD

By "trunk raising obliquely forward" is meant a diagonal motion of the trunk which combines trunk flexion and rotation. It is accomplished by the combined action of the external and internal oblique muscles in a diagonal line of pull.

The oblique trunk raising test is usually performed after the straight anterior trunk and leg-raising tests which already have revealed to the examiner much about the relative strength of individual abdominal and hip flexor muscles. Problems encountered in the oblique and anterior tests are similar if considerable imbalance of muscle strength exists.

Details concerning grading of oblique muscles will be found on p. 206. Grading of strength under 60% is complicated. The sections below on "Arm Pull and Push Movements" and "Deviations of the Umbilicus" contain suggestions for grading when marked weakness exists.

ARM PULL AND PUSH MOVEMENTS

Like trunk and leg movements, arm movements must be very accurately done to be used in testing abdominal strength. Arm movements done against resistance or held against pressure are used in abdominal muscle testing because unresisted arm movements do not demand action of trunk muscles for fixation.

Normally an upward movement of the arms in the forward plane requires back fixation; a downward movement in the forward plane requires abdominal fixation. When abdominal weakness exists, however, fixation for the downward pull or push of the arm may be provided by the back muscles alone.

For example, if a patient is placed in a supine position and given resistance to a downward pull of both arms, normal abdominal muscles will contract to fix the thorax firmly on the pelvis. However, if extensive abdominal weakness is present, the back will arch from the table and the thorax will pull away from the pelvis until it is firmly fixed by extension of the dorsal spine. The arching of the back stretches the abdominal muscles and they become firm under tension. The examiner must be careful not to mistake this firmness for tone due to actual contraction of the muscles.

In cross-sectional or diagonal arm movements, if the abdominal muscles are normal, the external oblique on the same side as the arm and the internal oblique on the opposite side contract to fix the thorax to the pelvis. If cross-sectional weakness exists in that line of pull, the opposite oblique muscles may act to give fixation. It is important that the examiner understand all of these complex actions of the muscles in order to give an accurate examination.

DEVIATIONS OF UMBILICUS AS USED TO INDICATE ABDOMINAL STRENGTH

Functional test movements used to determine strength of abdominal muscles cannot isolate upper from the lower rectus. Likewise no functional test movement can isolate part (b) external from the opposite part (b′) internal. This is because the muscle or part of the muscle is functionally only as strong as the fixation from the portion which completes its line of pull. (See figs. 110–114.) For maximum function, muscles require fixation from bone to bone. If there were a point of bony fixation in the midline of the abdomen transversely for the rectus, or longitudinally for the obliques, the portions could be isolated by test movements localized to each quadrant. The linea alba is not such a fixed attachment for the muscles.

It is possible, though, to determine imbalance to a considerable degree of accuracy by observing the deviations of the umbilicus. The umbilicus will deviate toward a strong or away from a weak quadrant. If, for example, three quadrants, the left external and both left and right internals, are equally strong and there is marked weakness of right external, the umbilicus will deviate decidedly toward the left internal. This happens not because the left internal is the strongest, but because it has no opposition in the right external. This shows deviation away from a weak quadrant. On the other hand deviation may mean that

there is one strong quadrant and that the other three portions are weak. The relative strengths must then be determined to a great extent by palpation and by the extent to which the umbilicus deviates during the performance of localized test movements.

An individual unfamiliar with the examination of abdominal muscles may find it very difficult to be sure of the deviations of the umbilicus. If a tape or cord is held transversely, then longitudinally over the umbilicus as the test movements are performed, the direction of the deviation can be readily determined. The umbilicus may deviate up or down from the transverse tape showing uneven pull of upper and lower rectus. If it also shows a deviation from the tape held longitudinally over the umbilicus it will exhibit an imbalance between the four quadrants.

Lines made with ink or flesh pencil on the anterior iliac crests, the costal margins, just above the pubis, and below the sternum may be an aid to the examiner. As the test movement is done, the tape is held from the umbilicus to the various marks. Actual shortening or stretch of the muscle can be detected as the movement is attempted.

There are times when the umbilicus deviates not because of a definite muscle pull but merely because a tilting of the pelvis or twist of the thorax places a stretch on one group of muscles. The tension, rather than an active contraction, draws the umbilicus out of position. This occurs frequently during movements using the arms or legs when care is not taken to keep the thorax and pelvis fixed, and especially if the back is permitted to arch. It is for this reason that the examiner must be sure whether the abdominal quadrant he is testing is really actively contracting before he uses the deviations of the umbilicus as being indicative of actual strength.

It is necessary to distinguish carefully between actual and apparent *deviations. The following* examples of apparent deviations will illustrate this point.

A tape is placed from the umbilicus to the sternum. The patient rolls his pelvis to flatten his back on the table, then attempts to raise his legs. In this instance, as he does so the back arches from the table due to the weakness of the anterior abdominals. *It may* be noted that the distance between the umbilicus and sternum is increased, and apparently the umbilicus deviates toward the lower rectus. This would lead to the impression that the lower rectus was stronger than the upper. Now if the tape is placed from the umbilicus to a line above the pubis and the test repeated it may be noted that the distance is increased even more than it was above the umbilicus and still the umbilicus moves slightly downward. The back arches as the legs are lifted, causing a stretch on the entire rectus, and especially on the lower rectus. In such a case the umbilicus might "deviate" downward and still the upper rectus might be stronger than the lower.

The preceding example illustrates the fact that a test movement which is so difficult that it places the muscles on a stretch, may cause the umbilicus to deviate due to the stretch rather than to the contraction.

The following example illustrates the fact that the deviation of the umbilicus may be misleading if the individual starts from a position of stretch (such as exists when the back is arched). In this instance it is assumed that the lower rectus is stronger than the upper.

A patient lies supine on the table with his back in a position of marked lordosis which exerts tension on the abdominal muscles. As he rolls his pelvis to flatten his back on the table, there may be a slight upward deviation of the umbilicus. This is due to the fact that the tension on the rectus, especially the weaker upper rectus, has been released, permitting the umbilicus to retract to a rest position.

To obtain actual deviations, the abdominal muscles should first be relaxed. The pelvis may be passively rolled backward, or the knees may be bent sufficiently to relax the back flat on *the table. Then the patient may be asked* to attempt head raising or "rolling his pelvis" (even though the back is already flat). If resistive arm and leg movements are used in testing they should be started from this relaxed

position also Movements should always be such that they produce actual shortening of the muscle Movements should not be so strenuous that they stretch the muscle When weakness is very apparent the initial test should be a mild active movement with resistance gradually applied. It should be noted first to what extent the muscle can approximate its origin and insertion and second how much pressure can be added before the pull "breaks" and the muscle starts to stretch

Grading Abdominal Muscles

ANTERIOR ABDOMINAL MUSCLES

As a preliminary to testing abdominal muscles the strength of the neck flexors and hip flexors should be determined (see pp 220 and 162) because their action is involved in the abdominal tests

Trunk flexibility should be checked so that restriction of motion will not be confused with muscle weakness

Examination of anterior abdominal muscles involves giving two separate tests (1) The trunk raising test and (2) the leg raising test

The trunk raising test is a *test movement* Usually the patient attempts first the movement as specified for a test of 100% strength. If he is unable to do it correctly he is given easier modifications of the test until he is successful in doing one (In dealing with paralytic cases which have obvious weakness of the part to be tested the examiner should modify the order of test procedures)

The leg-raising test is also a *test movement* Usually the patient attempts the 100% test movement first If the patient does not accomplish it correctly the examiner places the extended legs in a position slightly below a right angle with the table and watches the position of the pelvis while the patient lowers his legs slowly The angle which the legs make with the table at the moment that the pelvis begins to tilt anteriorly will determine the grade given to the 'lower abdominal muscles

100 percent

(1) With the hands clasped behind the head, the patient first flattens the lumbar spine by pelvic tilt then folds to sitting position The legs are not supported until trunk flexion is complete but may be supported as soon as the pelvis should normally begin flexing on the thighs. (If hip flexors are weak the 100% grading should be based on the patient's ability to complete his range of trunk flexion and hold against moderate pressure) (For explanation see p 180) (See figs 116 a and b)

(2) With hands clasped behind the head the patient rolls his pelvis backward and holds his lumbar spine flat on the table as the legs are raised and lowered (See fig 121)

80 percent

(1) Same as (1) under 100% except that arms are folded on the chest (See fig 124.)

(2) With the hands clasped behind the head the patient rolls his pelvis to flatten the lumbar spine The examiner then raises the patient's legs to an angle of approximately 40 degrees from the table and asks the patient to keep his back flat on the table while holding the legs in that position The ability to maintain this position of the pelvis and legs constitutes a grade of 80%

60 percent

(1) Same as (1) under 100 percent except that the arms are extended forward (See fig 125)

(2) Same as (2) under 80% except that legs are held at an angle of approximately 60 (See fig 126)

50 percent

(1) With arms extended forward the patient is able to roll his pelvis and lift his head and shoulders so that the region of the 7th cervical vertebra is about 4 or 5 inches from the table

(2) Same as (2) under 80% except that legs are held at an angle of approximately 80 from the table

Objective grading is quite easy for strengths of 50% and above Below 50% it is much more

there is one strong quadrant and that the other three portions are weak. The relative strengths must then be determined to a great extent by palpation and by the extent to which the umbilicus deviates during the performance of localized test movements

An individual unfamiliar with the examination of abdominal muscles may find it very difficult to be sure of the deviations of the umbilicus If a tape or cord is held transversely then longitudinally over the umbilicus as the test movements are performed, the direction of the deviation can be readily determined The umbilicus may deviate up or down from the transverse tape showing uneven pull of upper and lower rectus If it also shows a deviation from the tape held longitudinally over the umbilicus, it will exhibit an imbalance between the four quadrants

Lines made with ink or flesh pencil on the anterior iliac crests the costal margins, just above the pubis and below the sternum may be an aid to the examiner As the test movement is done the tape is held from the umbilicus to the various marks Actual shortening or stretch of the muscle can be detected as the movement is attempted

There are times when the umbilicus deviates not because of a definite muscle pull, but merely because a tilting of the pelvis or twist of the thorax places a stretch on one group of muscles The tension rather than an active contraction draws the umbilicus out of position This occurs frequently during movements using the arms or legs when care is not taken to keep the thorax and pelvis fixed and especially if the back is permitted to arch It is for this reason that the examiner must be sure whether the abdominal quadrant he is testing is really actively contracting before he uses the deviations of the umbilicus as being indicative of actual strength

It is necessary to distinguish carefully between actual and apparent deviations The following examples of apparent deviations will illustrate this point

A tape is placed from the umbilicus to the sternum The patient rolls his pelvis to flatten his back on the table then attempts to raise his legs In this instance as he does so the back arches from the table due to the weakness of the anterior abdominals It may be noted that the distance between the umbilicus and sternum is increased and apparently the umbilicus deviates toward the lower rectus. This would lead to the impression that the lower rectus was stronger than the upper Now if the tape is placed from the umbilicus to a line above the pubis and the test repeated it may be noted that the distance is increased even more than it was above the umbilicus and still the umbilicus moves slightly downward The back arches as the legs are lifted causing a stretch on the entire rectus and especially on the lower rectus In such a case the umbilicus might deviate downward and still the upper rectus might be stronger than the lower

The preceding example illustrates the fact that a test movement which is so difficult that it places the muscles on a stretch, may cause the umbilicus to deviate due to the stretch rather than to the contraction

The following example illustrates the fact that the deviation of the umbilicus may be misleading if the individual starts from a position of stretch (such as exists when the back is arched) In this instance it is assumed that the lower rectus is stronger than the upper

A patient lies supine on the table with his back in a position of marked lordosis which exerts tension on the abdominal muscles As he rolls his pelvis to flatten his back on the table there may be a slight upward deviation of the umbilicus This is due to the fact that the tension on the rectus especially the weaker upper rectus has been released permitting the umbilicus to retract to a rest position

To obtain actual deviations the abdominal muscles should first be relaxed The pelvis may be passively rolled backward or the knees may be bent sufficiently to relax the back flat on the table Then the patient may be asked to attempt head raising or "rolling his pelvis (even though the back is already flat) If resistive arm and leg movements are used in testing, they should be started from this relaxed

(2) If this test is done by the patient as a *test movement* he is asked to clasp his hands behind his head and raise his body diagonally in trunk flexion and rotation until both shoulders are well off the table. The *test position* is preferred because the movement is a difficult one for the patient to do accurately.

Whichever method is used the patient's legs must be held in position by the assistant (See fig. 127.) (The back must not be hyperextended in this test.)

80 percent

Ability to hold test position or do test movement as in 100% test except that arms are folded on chest and lower shoulder leaves the table only a few inches.

60 percent

Ability to hold the test position or do test movement as in 100% test except that arms are extended forward and the lower shoulder is barely lifted from the table. (The scapula of the upper shoulder should be entirely off the table.)

50 percent

With the examiner giving moderate resistance against a diagonally downward pull of the arm, the cross sectional pull of the oblique abdominal muscles will be very firm on palpation and will pull the costal margin toward the iliac crest.

If the arm is weak, pushing the shoulder upward from the table and holding against pressure may be substituted for the arm movement.

With the straight leg held in approximately 60 degrees hip flexion the examiner applies pressure against the thigh in a downward outward direction. The strength of oblique muscles should be sufficient to pull the iliac crest toward the opposite costal margin against this moderate pressure. (This test can only be used if hip flexor strength is good.)

40 percent

The patient is able to hold the back flat and approximate the iliac crest toward the opposite costal margin as he raises the leg actively (that is, against no resistance) and pulls the arm obliquely downward against slight resistance.

5 to 20 percent

If the weight of the leg and slight resistance against the arm causes separation rather than approximation in the diagonal pull as above, have the patient attempt to tighten the muscles pulling the costal margin toward the opposite iliac crest. Depend on palpation and reflex action for grading.

Part (a) External (upper anterior fibers). In head raising and forward trunk flexion movements the rib cage is normally depressed. In these tests and in diagonal arm pull movements (in which the pull is directed in line with these upper fibers) this upper part of the external oblique should pull downward on the rib cage. If the part is weak the rib cage will flare out and the thorax will be slightly elevated on the weak side.

In the head raising test it may be noted frequently that the costal angle changes, sometimes it is increased and other times decreased. If the upper fibers of the external oblique are strong and the fibers of the internal oblique weak the angle will be decreased due to the downward medialward pull of the external oblique fibers. If the upper fibers of the internal oblique are strong and the upper fibers of the external oblique are weak the angle will be increased due to the downward outward pull of the internal oblique. At other times, when upper fibers of both internal and external obliques are weak, the costal margin will flare out and the thorax will bulge laterally as the head is raised.

Part (c) Internal (low transverse fibers). No test movement can cause an approximation of parts to which the lower fibers of the *internal* are attached since these fibers extend across the lower abdomen from ilium to ilium (as do the lower fibers of the transversus abdominis). In pelvic roll, leg raising, and trunk raising movements however this part will become *tense if strong*. The degree of strength must be determined by palpation and by the ability of

difficult to grade accurately It is impractical to attempt to list all the possible combinations of abdominal muscle action that might be encountered Most of them can be interpreted adequately by using the principles suggested in this chapter Experience will enable the examiner to make increasingly fine distinctions

In the material below it is assumed that the necessary arm neck and leg muscles are strong Grading of the parts of the obliques and the recti separately is based mainly on the deviations of the umbilicus (see preceding sections p 203 to p 205) and on palpation for muscle tone

40 percent

With knees slightly flexed (blanket roll under them) have the patient roll his pelvis and raise his head. The patient is able to approximate the pubis and the sternum as the head is lifted

30 percent

The patient is able to approximate the pubis and sternum in the pelvic roll movement but as the weight of the head is lifted, the rectus "gives" and the thorax is elevated

5 to 20 percent

The patient can "set" or tense the abdominal muscles slightly but is actually unable to approximate the pubis and sternum in attempting the pelvic roll Depend on reflex action and palpation for grading

LATERAL ABDOMINAL MUSCLES

Before doing the following abdominal tests, test for the strength of the leg abductors arm adductors and lateral neck flexors. Test, also for passive lateral flexion of trunk

100 percent

Trunk flexion laterally in side lying to point of patient's maximum lateral flexion (Costal region closely approximates the iliac crest laterally See fig 123)

80 percent

Trunk flexion laterally in side-lying the under shoulder is raised about 4 inches from the *table*

50 to 60 percent

Trunk flexion laterally in side-lying the under shoulder is raised 1 to 3 inches from the table

30 to 50 percent

In side-lying firm fixation and approximation of the rib cage and iliac crest laterally during active leg abduction and arm adduction against moderate resistance

20 to 30 percent

Ability to approximate iliac crest toward rib cage laterally in side-lying but the lateral abdominals "give" and the distance is increased as the weight of the leg is raised in abduction, or the arm is adducted against moderate resistance

10 to 20 percent

Supine with back flat Ability to tighten the lateral abdominals drawing the pelvis up slightly

0 to 10 percent

Supine Palpate for tone when patient attempts to draw up hip or adduct arm against slight resistance.

OBLIQUE ABDOMINAL MUSCLES

These tests are for the External Oblique especially part (b) and the opposite Internal Oblique especially part b no attempt is made to outline grades for the other parts though some details in regard to them are discussed

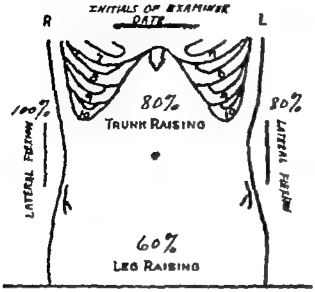
100 percent

(1) Patient clasps hands behind head. Examiner places the trunk in a position of flexion and rotation with both shoulders well off the table If the strength is less than 100%, the trunk will turn or drop out of the *test position*.

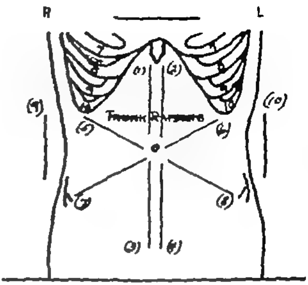
FIG 129

Shows anterior bulging of abdominal wall due to weak transversus abdominis The direction of the fibers is indicated by the horizontal lines of the muscle as drawn on the skin (The arms are held in this position to expose the skin drawing of the muscle)

The picture shows the subject standing in a position of mild lordosis A bulging due to a weak transversus may be found with or without a lordosis



(a)



(b)

FIG 128

the patient to compress the lower abdominal wall

Part (c) External and part (a) Internal (lateral fibers of each) In (1) lateral arm adduction and (2) leg abduction against resistance as well as (3) the lateral flexion tests in side-lying these parts of the external and internal obliques pull strongly in combined action In the side lying position movements of the thorax and pelvis in flexion extension or rotation will denote differences in strength of the external and internal oblique muscles A tendency toward flexion of the thorax with backward rotation indicates a stronger internal oblique A posterior pelvic tilt with forward rotation of the thorax indicates a stronger external oblique pull.

Transversus Abdominis During forward flexion in the supine position and hyperextension of the trunk in the prone position there will be bulging laterally if the transversus abdominis is weak With a normal transversus there will be a retraction of the lateral and anterior abdominal wall during these trunk movements

Recording Abdominal Muscle Grades

Abdominal muscle grades are recorded in two different ways depending on the amount of strength

When marked weakness or imbalance exists, it is necessary to indicate findings in relation to specific muscle action Figure 128 b illustrates how lines are drawn in to indicate the various muscles that may be graded Lines (1) and (2) represent right and left upper rectus respectively (3) and (4) right and left lower rectus (5) and (6) right and left external obliques (7) and (8) right and left internal obliques, and (9) and (10) represent the right and left lateral abdominals In recording the percentage grade for each muscle is placed on the line which represents it in the abdominal drawing

When strength is *50%* or better in the trunk and leg raising tests it is usually sufficient to grade on the basis of these tests. (See 128 a) There seldom is intrinsic imbalance between parts of the rectus or the obliques to necessitate grading parts separately if these tests show *50%* or better

FIG 120

Shows anterior bulging of abdominal wall due to weak transversus abdominis The direction of the fibers is indicated by the horizontal lines of the muscle as drawn on the skin (The arms are held in this position to expose the skin drawing of the muscle)

The picture shows the subject standing in a position of mild lordosis A bulging due to a weak transversus may be found with or without a lordosis

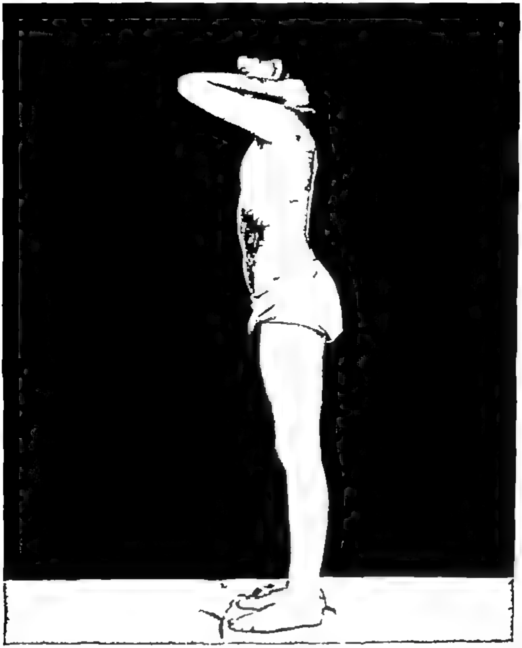


Fig 130 Lumbar lordosis as associated with weak external oblique muscles

A thrust of the knees in the direction of hyper extension typically accompanies lordosis. Hip flexor tightness is frequently found in this type of posture The left external oblique muscle as drawn on the skin shows line of the fibers (Arms are held in this position to expose the drawing)

FIG 131 Anterior displacement of the pelvis as associated with external oblique weakness

This displacement may be mistaken for a lordosis but is not one because there is no anterior tilt of the pelvis (Sometimes the pelvis is tilted posteriorly) The decreased angle between the foot and lower leg and the posterior displacement of the thorax accompany anterior displacement of the pelvis Frequently a weakness of the hip flexors will be found in this type of posture The left external oblique muscle drawn on the skin shows the line of the fibers (The arms are held in this position to expose the skin drawing)

(a)

(b)

FIG 132 Quadratus lumborum

(a) Test Quadratus lumborum

PATIENT

Prone

FIXATION

By muscles which hold the leg firmly in the acetabulum

TEST

Elevation of the pelvis laterally Leg is placed in slight extension and in the degree of abduction which corresponds with the line of fibers of the quadratus lumborum (See fig b)

PRESSURE

Given in the form of traction on the leg directly opposing the line of pull of the quadratus If hip muscles are weak pressure may be given against the pelvis in opposition to the quadratus pull

(b) Line drawing Shows line of muscle fibers with leg in test position.

The quadratus lumborum acts along with other muscles in lateral trunk flexion (see p 187) It is difficult to palpate this muscle because it is attached to the lumbar fascia which underlies part of the latissimus dorsi the posterior fibers of the external and internal oblique and the transversus abdominis Though the quadratus lumborum enters into the motion of elevation of the pelvis in the standing position or in walking the standing position does not offer a satisfactory position for testing Elevation of the right side of the pelvis in standing depends as much if not more on the downward pull by the left abductors as it does on the upward pull of right lateral abdominals

The test illustrated should not be considered as limited to quadratus lumborum action but as giving the most satisfactory differentiation that can be obtained This text does not recommend attempting to grade numerically the strength of this muscle It seems preferable to record whether it appears weak or strong

Weakness Shortness and Contracture of Abdominal Muscles

TRANSVERSUS ABDOMINIS

WEAKNESS : Permits a bulging of the anterior abdominal wall without direct effect on the tilt or rotation of the pelvis or thorax (See fig 129)

SHORTNESS : Seldom if ever seen

RECTUS ABDOMINIS

WEAKNESS Permits a separation of the pubis and sternum with resultant lordotic posture In supine position a weakness of this muscle results in a decrease in the ability to flex the pelvis on the thorax or the thorax on the pelvis

SHORTNESS Causes a dorso-lumbar kyphosis with limitation of spine extension

INTERNAL OBLIQUE

WEAKNESS *Bilateral* weakness results in the inability to flex the thorax on the pelvis from a supine position (as indicated by the trunk raising test)

Unilateral weakness permits rotation of the thorax forward on the side of weakness

SHORTNESS *Bilateral* shortness depresses the thorax anteriorly tending to pull the upper trunk into a position of kyphosis The costal angle will tend to remain spread

Unilateral shortness rotates the thorax backward on the side of shortness.

EXTERNAL OBLIQUE

WEAKNESS *Bilateral* weakness results in either an anterior pelvic tilt (with lordosis) (see fig 130) or an anterior displacement of the pelvis (see fig 131)

Unilateral weakness permits a rotation of the thorax backward on the side of weakness.

SHORTNESS : *Bilateral* shortness seldom is seen but the effect of shortness is a posterior tilt of the pelvis (When it occurs muscle shortness of the external oblique is more apt to accompany pelvic tilt as a result rather than as a cause)

Unilateral shortness causes rotation of the thorax forward on the side of shortness as seen in cases of scoliosis A contracted or short external oblique (postero-lateral part) will cause a scoliosis of the dorsal spine just as a contracted sterno-cleido-mastoid will cause a *torticollis of the cervical spine*

Internal and External Oblique (Middle and lateral parts of both are included Lower transverse fibers of the internal and the upper anterior fibers of the external are not included)

WEAKNESS Weakness of the external and internal oblique *on the same side* Permits separation of the costal margin and iliac crest laterally resulting in a C-curve convex toward the side of weakness accompanied by a minimum amount of rotation

Weakness *of the external and internal oblique on the opposite sides* (e.g weakness of the right external and left internal) A weakness of external oblique on the right and the internal oblique on the left allows a separation of the right costal margin and the left iliac crest The result is a backward rotation of the thorax on the right and counter-clockwise rotation of the pelvis (that is backward on the left, forward on the right) The left iliac crest drops The internal oblique influences the lateral pelvic *tilt more than does the external* while the external influences the rotation of the thorax more than does the internal oblique

SHORTNESS Shortness or contracture of the external and internal oblique *on the same side* Approximates the iliac crest and the costal margin laterally thrusting the spine into a C-curve convex toward the opposite side (i.e., a contracted right external and internal will produce a left C-curve)

Shortness or contracture of the external *and internal oblique on opposite sides* (e.g., contracted left external and right internal) Causes an approximation of the left costal margin toward the right iliac crest with elevation of the right iliac crest and rotation of the thorax forward on the left (backward on the right)

The picture of shortness or contracture of the left external anc the right internal will usually

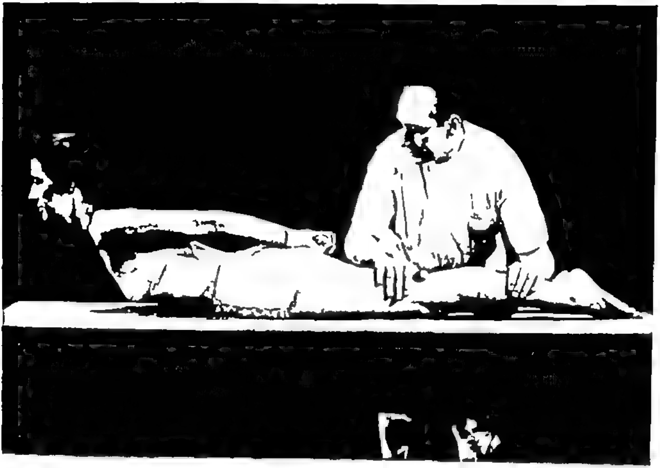


FIG 133 Back extensors

PATIENT

Prone

FIXATION

The examiner holds the legs firmly down on the table The gluteal and hamstring muscles fix the pelvis on the thigh and leg

TEST

Hyperextension of the lumbar and cervical spine with extension of the dorsal spine

PRESSURE

Against the dorsal spine in a downward direction toward the table

Weakness Shortness and Contracture of Abdominal Muscles

TRANSVERSUS ABDOMINIS

WEAKNESS Permits a bulging of the anterior abdominal wall without direct effect on the tilt or rotation of the pelvis or thorax. (See fig 129)

SHORTNESS Seldom, if ever seen.

RECTUS ABDOMINIS

WEAKNESS Permits a separation of the pubis and sternum with resultant lordotic posture In supine position, a weakness of this muscle results in a decrease in the ability to flex the pelvis on the thorax, or the thorax on the pelvis.

SHORTNESS Causes a dorso-lumbar kyphosis with limitation of spine extension.

INTERNAL OBLIQUE

WEAKNESS *Bilateral* weakness results in the inability to flex the thorax on the pelvis from a supine position (as indicated by the trunk raising test)

Unilateral weakness permits rotation of the thorax forward on the side of weakness

SHORTNESS *Bilateral* shortness depresses the thorax anteriorly tending to pull the upper trunk into a position of kyphosis The costal angle will tend to remain spread.

Unilateral shortness rotates the thorax backward on the side of shortness.

EXTERNAL OBLIQUE

WEAKNESS *Bilateral* weakness results in either an anterior pelvic tilt (with lordosis) (see fig 130) or an anterior displacement of the pelvis (see fig 131)

Unilateral weakness permits a rotation of the thorax backward on the side of weakness

SHORTNESS *Bilateral* shortness seldom is seen, but the effect of shortness is a posterior tilt of the pelvis (When it occurs muscle shortness of the external oblique is more apt to accompany pelvic tilt as a result rather than as a cause.)

Unilateral shortness causes rotation of the thorax forward on the side of shortness as seen in cases of scoliosis A contracted or short external oblique (postero-lateral part) will cause a scoliosis of the dorsal spine just as a contracted sterno-cleido-mastoid will cause a torticollis of the cervical spine

Internal and External Oblique (Middle and lateral parts of both are included. Lower transverse fibers of the internal and the upper anterior fibers of the external are not included)

WEAKNESS Weakness of the external and internal oblique *on the same side* Permits separation of the costal margin and iliac crest laterally resulting in a C-curve convex toward the side of weakness accompanied by a minimum amount of rotation.

Weakness of the external and internal oblique *on the opposite sides* (e.g weakness of the right external and left internal) A weakness of external oblique on the right and the internal oblique on the left allows a separation of the right costal margin and the left iliac crest. The result is a backward rotation of the thorax on the right, and counter-clockwise rotation of the pelvis (that is backward on the left forward on the right) The left iliac crest drops. The internal oblique influences the lateral pelvic tilt more than does the external, while the external influences the rotation of the thorax more than does the internal oblique

SHORTNESS Shortness or contracture of the external and internal oblique *on the same side* Approximates the iliac crest and the costal margin laterally thrusting the spine into a C-curve convex toward the opposite side (i.e., a contracted right external and internal will produce a left C-curve)

Shortness or contracture of the external and internal oblique *on opposite sides* (e.g., contracted left external and right internal) Causes an approximation of the left costal margin toward the right iliac crest, with elevation of the right iliac crest and rotation of the thorax forward on the left (backward on the right)

The picture of shortness or contracture of the left external and the right internal will usually

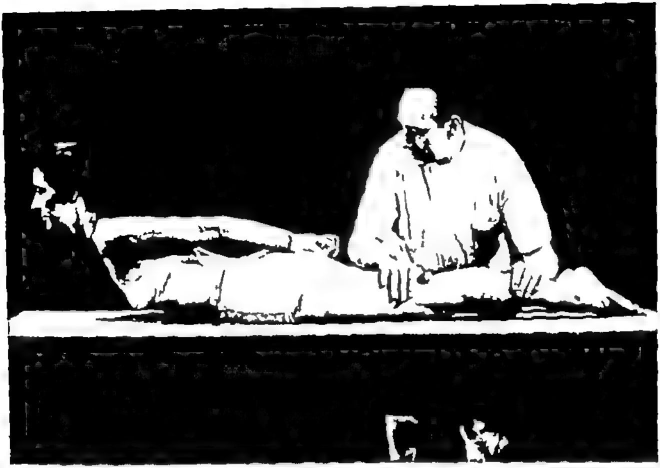


Fig 133 Back extensors

PATIENT

Prone

FIXATION

The examiner holds the legs firmly down on the table. The gluteal and hamstring muscles fix the pelvis on the thigh and leg

TEST

Hyperextension of the lumbar and cervical spine with extension of the dorsal spine

PRESSURE

Against the dorsal spine in a downward direction toward the table

be found along with weakness of the right external and the left internal. This is seen in the typical right dorsal left lumbar scoliosis which results from imbalance of the abdominal muscles

Posterior Trunk Muscles

The erector spinae muscles may be considered the most important of all trunk muscles. That abdominal muscles are discussed in detail and erector spinae muscles given relatively little emphasis is based on several factors. Low back muscle weakness is seldom encountered except in paralytic cases. The incidence among non paralytic (so-called normal) individuals *is about 3 or 4 per 1000* individuals. Abdominal weakness is frequently encountered. Abdominal muscles can be tested individually to a great extent while the erector spinae can be tested only as a group

The erector spinae are assisted in back extension by latissimus dorsi quadratus lumborum and trapezius. The combined action of all posterior muscles is tested in the Back Extensor test which follows. (Individual tests for all except erector spinae are described elsewhere.)

GRADING

100 percent

The patient will complete the spine extension movement and hold against maximum pressure

80 percent

The patient will complete the spine extension movement and hold against slight pressure.

60 percent

The patient will almost complete the spine extension movement

50 percent

The patient will be able to lift the thorax so that the xiphoid process of the sternum is raised from the table

If there is imbalance or if general strength is below 50% the examination involves several factors

When marked weakness is present usually such weakness extends throughout the entire back. A head raising movement which would furnish a slight resistance against other extensors for the purpose of grading can seldom be employed. Palpation and observation of the *muscle actions in the upper and lower back* must constitute the basis of grading

When the low back is strong and the upper back is weak, an attempt to extend will result in hyperextension of the low back by the erector spinae tilting the pelvis forward, but the thorax will not be lifted from the table

Weakness: *Bilateral* weakness of the spine extensor muscles will result in a dorsal-lumbar kyphosis

Unilateral weakness will result in a lateral curvature with convexity toward the weak side

Shortness or Contracture. *Unilateral* contracture results in a scoliosis with convexity toward the opposite side

Bilateral contracture of the low back muscles results in a lordosis

Contracture of the upper back is seen, not infrequently among adults who during their childhood participated in strong hyperextension activities (as associated with acrobatic dance movements). It appears as a flattening and even slight hyperextension of the dorsal spine. The scapulae are rather prominent because of the abnormal contour of the upper back.

Weakness Shortness and Contracture of Latissimus Dorsi and Trapezius as Related to the Trunk

LATISSIMUS DORSI

(For Weakness and Shortness as related to the arm, see p 112.)

Shortness (as related to the trunk) *Unilaterally* Depresses the shoulder and displaces the thorax forward and toward the opposite side. In a right C-curve the left latissimus dorsi usually is short.

Bilaterally Latissimus dorsi tightness tends to depress the shoulders down and forward by its action on the humerus

This muscle comes into action during a trunk movement (see fig 116 a) in the same manner

that it tends to become shortened in a bad kyphosis case

There is an apparent discrepancy between the unilateral rotation action on the thorax and the bilateral flexion action. This occurs because the latissimus may act in trunk flexion or extension. Likewise it is referred to at times as an accessory muscle of inspiration or of expiration.

Shortness of the latissimus may be found in individuals who have walked with crutches for a prolonged period of time.

WEAKNESS. The strength of lateral trunk flexion is diminished.

The thorax loses the postero-lateral fixation of this muscle and tends to bulge postero-laterally. Because it is an accessory muscle of respiration weakness interferes to some extent with forced expiration as in coughing.

TRAPEZIUS (MIDDLE AND LOWER)

(For WEAKNESS and SHORTNESS as related to the arm see p. 110.)

WEAKNESS (as related to the trunk). The middle and lower parts of the trapezius reinforce the dorsal erector spinae in maintaining dorsal spine extension. With weakness of the trapezius the dorsal spine tends to go into a kyphosis. The scapulae are abducted and elevated in a forward round-shoulder position.

SHORTNESS. Rarely seen.

CHAPTER VI

NECK, FACIAL THROAT, AND RESPIRATORY MUSCLES

The neck flexors and extensors are graded on the basis of anti-gravity range of motion and pressure against the held position as Class II muscles. (See p 11)

In most of the facial muscles the evaluation of strength is based on the degree of expression possible There is an element of range of motion but not in the sense of an arc of motion because no joint is involved

In the muscles of the eye there is this same factor of range of motion.

In the muscles of mastication, which move the lower jaw the factors of motion and pressure are involved.

The gravity factor is not employed in any of the above tests

The Cranial Nerve Chart (p 30) may be used for recording the evaluation of facial muscles. The grades of zero 'weak' and 'normal' furnish adequate description of the function of most of these muscles

The Respiratory Muscle Chart (Chapter II) lists the primary and accessory muscles of respiration and may be used for recording evaluation of these muscles.

THE FOLLOWING MUSCLE TEST ACTIONS ARE LISTED BUT NOT ILLUSTRATED

Eye

RECTUS INFERIOR AND OBLIQUUS SUPERIOR. Have the patient look straight downward toward the mouth

Ear

AURICULARIS SUPERIOR ANTERIOR AND POSTERIOR. These muscles may move the ear but most people cannot perform the movement voluntarily

Tongue

EXTRINSIC AND INTRINSIC MUSCLES With the mouth open, have the patient perform the following movements—protrude the tongue forward draw the tongue backward move the tongue upward toward the nose move the tongue downward toward the chin move the tongue toward the right cheek and toward the left cheek, curl the tip of the tongue backward and curl the sides of the tongue upward

Palate

LEVATOR VELI PALATINI TENSOR VELI PALATINI MUSCULUS UVULAE. These muscles raise and make tense the soft palate and uvula as in gagging To examine for weakness or imbalance as in bulbar poliomyelitis cases have the patient with mouth wide open say ah" The examiner will note a deviation of the uvula away from the side of the weakness if one side is weak or paralyzed

GLOSSOPALATINUS AND PHARYNGOPALATINUS These muscles constrict the anterior and posterior arches of the fauces as in swallowing

Pharynx

STYLOPHARYNGEUS SALPINGOPHARYNGEUS, PHARYNGOPALATINUS These muscles raise the pharynx and larynx and dilate the pharynx as in the first part of the act of swallowing

CONSTRICTORS The constrictors contract successively as in swallowing

Larynx

INTRINSIC MUSCLES These muscles open the throat for forced deep inhalation and close the throat for swallowing and for clear phonation

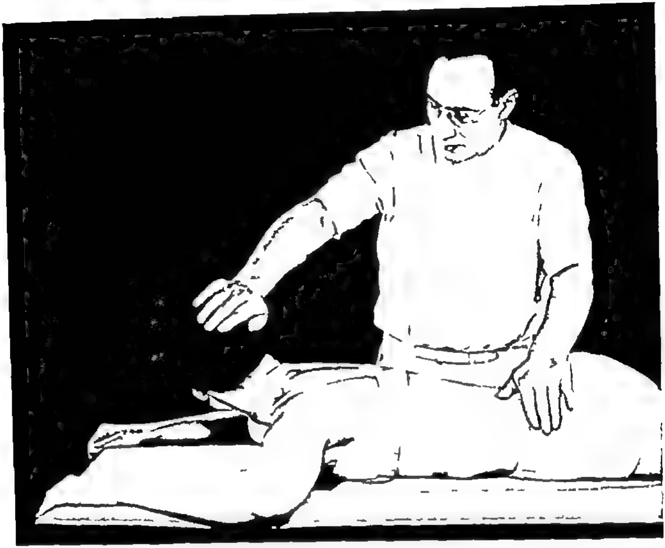


FIG 134 Postero-lateral neck extensors

PATIENT

Prone with the elbows bent and the hands resting on table overhead

FIXATION

Usually none necessary by examiner

TEST

Postero-lateral neck extension

PRESSURE

Against the postero-lateral aspect of the head in a downward direction

NOTE

In this test the face is rotated toward the side being tested

The test performance depends on strong action of the splenius and other muscles which act along with the splenius in its direction of pull.

In contrast the upper trapezius test (see fig 59) requires a rotation of the face toward the opposite side

Fig 135 Anterior neck flexors

Patient

Supine with the elbows bent and the hands over head resting on the table

Fixation

Anterior abdominal muscles must be strong enough to give anterior fixation of thorax to pelvis before the head can be raised by the neck flexors If abdominal muscles are weak the examiner can give fixation by firm downward pressure on the thorax All children (five years and under) should have fixation of the thorax by the examiner during the test (modified for this age group as described below under Test)

Test

Flexion of the cervical spine by lifting the head up from the table with the chin depressed and approximated toward the sternum. (Children five and under should be tested by an assisted test movement or as follows the effort is made to flatten the cervical spine on the table approximating the chin toward the sterno-clavicular region Resistance applied against the chin may be used as a measure for grading)

Pressure

Against the forehead in a downward direction

Note

The anterior vertebral neck flexors are aided by the sterno-cleido-mastoid anterior scaleni and supra and infra hyoids in this movement The platysma will attempt to aid when flexors are very weak

Weakness

Results in hyperextension of the cervical spine in a forward head position.

Contracture

A neck flexion contracture is rarely seen

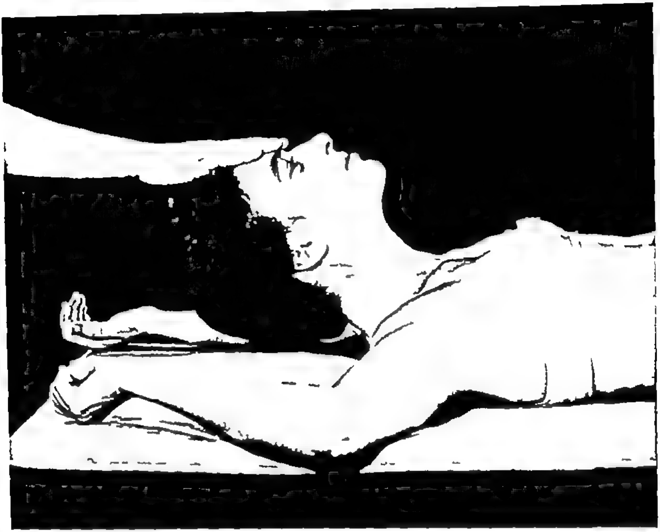


FIG 136 Error in testing neck flexors

If anterior vertebral neck flexors are weak and the sterno-cleido-mastoid muscles strong an individual can raise the head up from the table (as illustrated) and can hold against pressure but this is not an accurate test for neck flexors Action is accomplished chiefly by the sterno-cleido mastoids aided by the anterior scaleni and the clavicular portion of the upper trapezius

FIG 137 Antero-lateral neck flexors

PATIENT

Supine with elbows bent and hands over head resting on the table

FIXATION

Same as for anterior neck flexors

TEST

Antero-lateral neck flexion

PRESSURE

Against the temporal region of the head in an obliquely downward direction

NOTE

The muscles acting in this test are chiefly sterno-cleido-mastoid and anterior scaleni

With neck muscles just strong enough to hold but not strong enough to actually flex a patient frequently raises the head from the table by raising the shoulders He does so especially on these tests for right and left flexors because he attempts to aid himself by taking some weight on the elbow or hand in order to push the shoulder from the table To avoid this hold the patient's shoulder flat on the table

FIG 138 Frontalis

Test Have the patient raise the eyebrows wrinkling the forehead as in surprise or fright

FIG 139 Corrugator

Test Have the patient draw the eyebrows together as in frowning.

FIG 140 Orbicularis Oculi

Test Have the patient close the eyelids firmly forming wrinkles radiating from the outer angles

Fig 141 Dilatator Naris

Test Have the patient widen the apertures of the nostrils.

FIG. 142. Depressor Septi and Nasalis

Test. Have the patient draw the point of the nose downward, narrowing the nostrils.

Fig 143 Procerus

Test Have the patient draw down the skin between the eyebrows and pull the skin of the nose upward forming wrinkles at the root of the nose

FIG 144 Mentalis

Test Have the patient raise the skin of the chin and protrude the lower lip as in pouting.

Fig 145 Risorius

Test Have the patient draw the angle of the mouth backward as in grinning

FIG 146 Zygomaticus

Test Have the patient move the angle of the mouth upward and outward as in smiling

FIG 147 Caninus

Test Have the patient draw the angle of the mouth straight upward deepening the furrow from the side of the nose to the side of the mouth

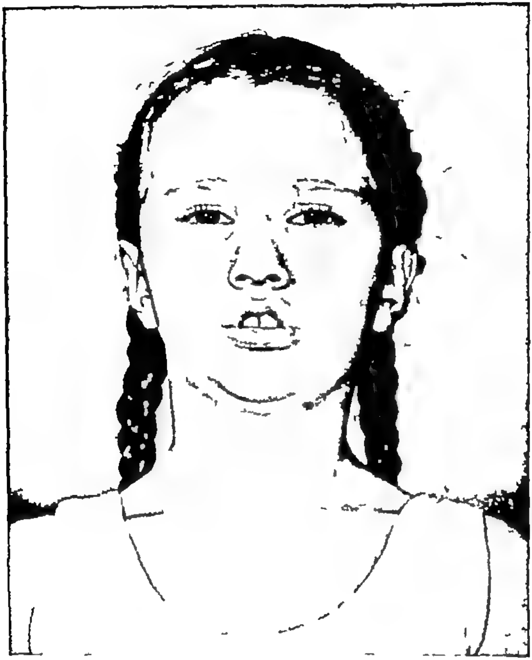


Fig 148 Quadratus Labii Superioris

Test Have the patient raise and protrude the upper lip

Fig 149 Orbicularis Oris

Test Have the patient close the lips and protrude them forward

FIG 160 Buccinator

Test Have the patient press the cheeks firmly against the side teeth pulling back the angle of the mouth (Drawing the chin backward as seen in this illustration, is not part of the buccinator action)

Fig 151 Triangularis

Test Have the patient draw down the angles of the mouth

Fig 152 Platysma and Quadratus Labii Inferioris

Test Have the patient draw the lower lip and angle of the mouth downward and outward tensing the skin over the neck

Fig 153 Pterygoideus Internus and Externus

Test Have the patient protrude the lower jaw on each side (Protrusion toward the right tests action of the muscles on the left side.)

FIG 154 Temporalis, Masseter and Pterygoideus Internus

Test Have the patient bite firmly on each side.

Fig 155 Digastric and Suprahyoid Muscles

Fixation The infrahyoid muscles furnish fixation of the hyoid bone during the action of these muscles

Test Have the patient depress the lower jaw against resistance.

Fig 106 Infrahyoid Muscles

(a) Relaxed position
(b) Test Have the patient depress the hyoid bone (as illustrated)

FIG 157 Levator Palpebrae Superioris Rectus Superior and Obliquus Inferior

Test Levator Palpebrae Superioris Have the patient raise the upper eye lid.
Test Combined action of the Rectus Superior and Obliquus Inferior Have the patient look straight upward toward the brow

FIG 158 Rectus Medialis and Rectus Lateralis

Test Rectus Medialis. Have the patient look horizontally inward toward the nose (Right illustrated.)

Test Rectus Lateralis Have the patient look horizontally outward away from the nose (Left illustrated.)

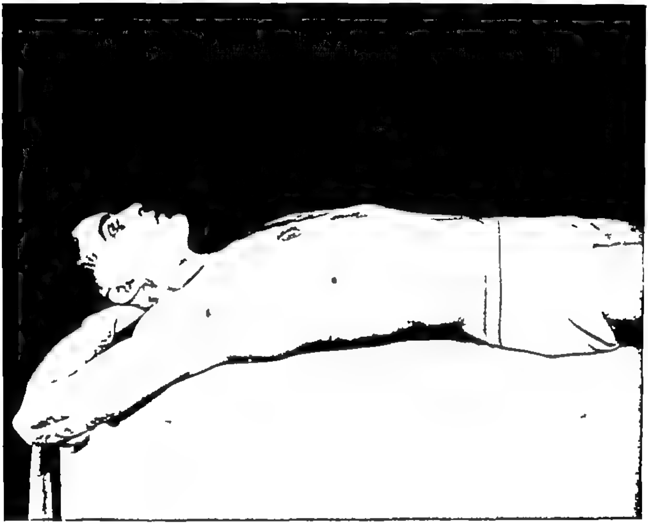


FIG 159 Normal inspiration with intercostal and diaphragmatic action

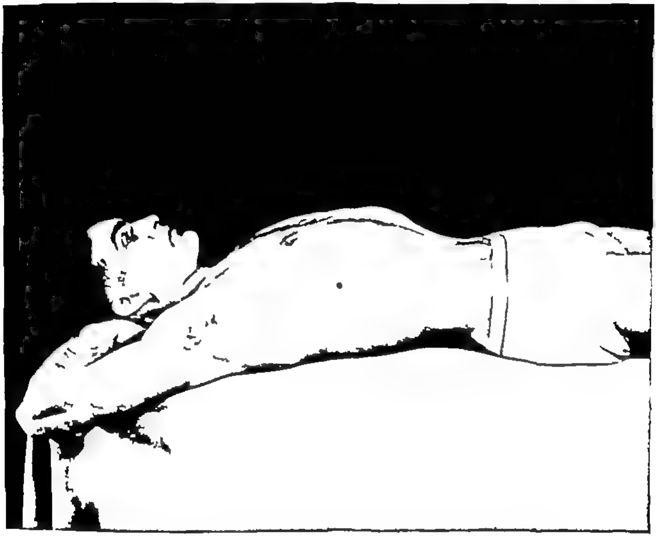


FIG. 100. Deep inspiration with intercostal expansion only

FIG 161 Inspiration with diaphragmatic action but no intercostal action

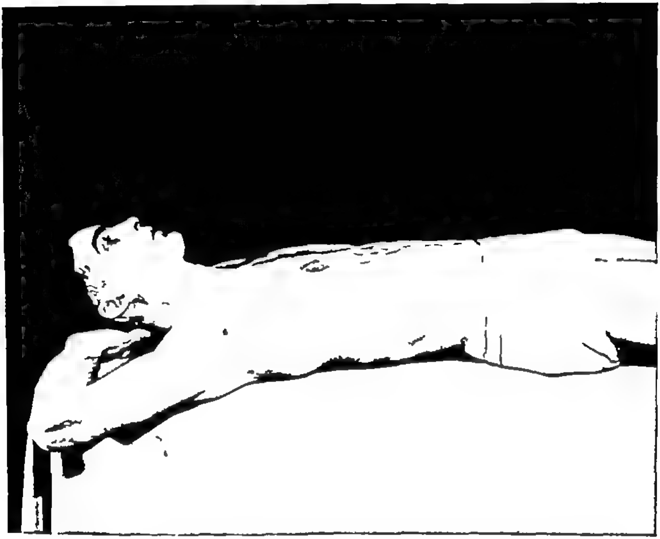


Fig 162 Forced expiration with intercostal and abdominal muscle action

APPENDIX

Origins and Insertions of Muscles Grouped According to Joint Action

	Origin	Insertion
	THUMB	
Flexion Flexor Pollicis Longus (both joints)	Volar surface of body of radius below tuberosity and medial epicondyle of humerus.	Base of distal phalanx of thumb
Flexor Pollicis Brevis (metacarpo-phal. joint)	**Superficial head:** transverse carpal ligament and greater multangular bone. **Deep head:** ulnar side of first metacarpal bone	Base of prox. phalanx of thumb radial and ulnar sides
Extension Extensor Pollicis Longus (both joints)	Middle 1/3 of dorsal surface of ulna	Base of distal phalanx of thumb
Extensor Pollicis Brevis (metacarpo-phal. joint)	Middle 1/3 of dorsal surface of radius.	Base of prox. phalanx of thumb
Adduction Adductor Pollicis Obliquus	Capitate and upper 1/4 of 3rd metacarpal	Ulnar side of base of prox. phalanx of thumb
Adductor Pollicis Transversus	Volar surface of 3rd metacarpal bone	Ulnar side of base of prox. phalanx of thumb
First Dorsal Interosseus	See under Fingers	
Abduction Abductor Pollicis Longus	*Dorsal surface of middle 1/3 of* body of radius, radial side of ulna and interosseus membrane.	Base of first metacarpal bone radial side
Abductor Pollicis Brevis	Transverse carpal ligament, ridge of greater multangular bone	*Radial side of base of prox. phalanx* of thumb
Opposition Opponens Pollicis	Greater multangular bone and transverse carpal ligament	Radial side of first metacarpal entire length
	FINGERS	
Flexion Flexor Digitorum Profundus (all joints)	Ventral surface extending around to medial half of dorsal surface of upper 3/4 of ulna	By 4 tendons into base of distal phalanges, ventral surface
Flexor Digitorum Sublimis (prox. interphalangeal and metacarpophalangeal *joints*)	**Humeral head:** medial epicondyle of humerus ***Ulnar head:*** *medial side of coronoid* process **Radial head:** oblique line of radius	Sides of middle phalanges.

UPPER EXTREMITY AND SCAPULAR MUSCLES—*Continued*

	Origin	Insertion
	FINGERS—*Continued*	
Lumbricales (metacarpo-phalangeal joint)	**First and Second**: radial surface of first and second flexor profundus tendons respectively **Third**: adjacent sides of second and third profundus tendons **Fourth**: adjacent sides of third and fourth profundus tendons.	Into the respective tendon of Extensor digitorum communis
Flex. Dig. Quinti	Hamate bone and transverse carpal ligament	Ulnar side of base of prox. phalanx of 5th digit
Extension		
Extensor Digitorum Communis (all joints)	Lateral epicondyle of humerus.	By tendons into middle and distal phalanges of fingers, dorsal surface
Extensor Indicis Proprius (all joints of index fingers)	Lower 1/3 (upper part) of dorsal surface of ulna	Into first tendon of extensor digitorum communis.
Extensor Min. Digiti (all joints)	From Common Extensor tendon	Into tendon of Ext. dig. com. dorsal surface of prox. phalanx of 5th digit
Interossei Lumbricales (interphalangeal joints)	See below See above	
Adduction		
Palmar Interossei (3)	**First**: ulnar side of second metacarpal bone **Second**: radial side of fourth metacarpal bone **Third**: radial side of fifth metacarpal bone	Into Ext. dig. com. tendon and bases of prox. phal. as follows: 1. Ulnar side of index finger 2. Radial side of ring finger 3. Radial side of little finger
Abduction		
Dorsal Interossei (4)	**First**: *Lateral head*: proximal 1/2 of ulnar border of first metacarpal bone *Medial head*: radial border of second metacarpal bone **Second, third and fourth**: adjacent sides of metacarpal bones in each interspace	Into Ext. dig. com. tendon and bases of prox. phal. as follows: 1. Radial side of index finger 2. Radial side of middle finger 3. Ulnar side of middle finger 4. Ulnar side of ring finger

UPPER EXTREMITY AND SCAPULAR MUSCLES—*Continued*

	Origin	Insertion
FINGERS—*Continued*		
Abduction—Continued Abductor Digiti Quinti	Tendon of Flexor carpi ulnaris and pisiform bone	Ulnar side of base of prox. phalanx of fifth digit
Opposition of little finger Opponens Digiti Quinti	Hamate bone and transverse carpal ligament	Ulnar side of fifth metacarpal entire length.
WRIST		
Flexion. Flexor Carpi Radialis	Medial epicondyle of humerus	Base of 2nd metacarpal bone and a slip to 3rd metacarpal bone
Flexor Carpi Ulnaris	Humeral head medial epicondyle of humerus Ulnar head: medial margin of olecranon dorsal border of ulna, upper 2/3	Pisiform bone and by ligament to hamate and fifth metacarpal bones.
Palmaris Longus	Medial epicondyle of humerus.	Transverse carpal ligament lower part of palmar aponeurosis
Flexor Digitorum Sublimis Flexor Digitorum Profundus Flexor Pollicis Longus	See under Fingers	
Extension Extensor Carpi Ulnaris	Lateral epicondyle of humerus and dorsal border of ulna	Base of 5th metacarpal bone ulnar side
Extensor Carpi Radialis Longus	Lateral supracondylar ridge of humerus lower 1/3	Dorsal surface of base of 2nd metacarpal bone radial side
Extensor Carpi Radialis Brevis	Lateral epicondyle of humerus.	Dorsal surface of base of 3rd metacarpal bone radial side
Extensor Digitorum Communis Extensor Indicis Proprius Extensor Digiti Quinti Proprius	See under Fingers	
Extensor Pollicis Longus Extensor Pollicis Brevis Abductor Pollicis Longus	See under Thumb	

UPPER EXTREMITY AND SCAPULAR MUSCLES—*Continued*

	Origin	Insertion
	FOREARM	
Supination		
Biceps Brachii	**Short head** coracoid process of scapula **Long head** supra-glenoid tuberosity of scapula	Tuberosity of radius.
Brachio-radialis (to mid line)	Lateral supracondylar ridge of humerus, upper 2/3	Styloid process of radius
Supinator	Lateral epicondyle of humerus and radial side of upper 1/4 of ulna, below radial notch	Dorsal and lateral surfaces of upper 1/3 of body of radius.
Pronation		
Pronator Teres	**Humeral head** immediately above medial epicondyle of humerus **Ulnar head:** medial side of coronoid process of ulna.	Middle of lateral surface of radius.
Pronator Quadratus	Medial side volar aspect of distal 1/4 of ulna.	Lateral side volar surface of distal 1/4 of radius
Brachio-radialis (to mid line)	See above	
Flexor Carpi Radialis	See under Wrist	
	ELBOW	
Flexion		
Biceps Brachii	See under Forearm	
Brachialis	Lower 1/2 of anterior surface of humerus	Tuberosity and Coronoid process of ulna
Brachio-radialis Pronator Teres	See under Forearm	
Flexor Carpi Radialis Flexor Carpi Ulnaris Palmaris Longus	See under Wrist	
Flexor Digitorum Sublimis Flexor Pollicis Longus	See under Fingers See under Thumb	

UPPER EXTREMITY AND SCAPULAR MUSCLES—*Continued*

	Origin	Insertion
ELBOW—*Continued*		
Extension.		
Triceps Brachii	**Long head** infra-glenoid tuberosity of scapula **Lateral head** lateral and posterior surfaces of upper 1/2 of body of humerus **Medial head** lower 2/3 of medial and posterior surfaces of humerus	Posterior surface of olecranon process of ulna
Anconeus	Lateral epicondyle of humerus-posterior surface	Olecranon process and upper 1/4 of dorsal surface of body of ulna.
Extensor Carpi Radialis Longus Extensor Carpi Radialis Brevis Extensor Carpi Ulnaris	See under Wrist	
Extensor Digitorum Communis	See under Fingers	
SHOULDER		
Flexion		
Coraco-brachialis	Coracoid process of scapula	Antero-medial surface of middle of shaft of humerus, opposite deltoid tuberosity
Biceps Brachii	See under Forearm	
Pectoralis Major	**Clavicular part** anterior surface of sternal 1/2 of clavicle **Sternal part** anterior surface of sternum and cartilages of first 6 or 7 ribs	Into crest of greater tubercle of humerus.
Anterior Deltoid	See below	
Extension		
Latissimus Dorsi	Spinous processes of last 6 thoracic vertebrae last 3 or 4 ribs through the lumbo-dorsal facia from the lumbar and sacral vertebra and posterior 1/3 of external lip of iliac crest.	Intertubercular groove of humerus
Subscapularis	Subscapular fossa of scapula	Lesser tuberosity of humerus and shoulder joint capsule

UPPER EXTREMITY AND SCAPULAR MUSCLES—*Continued*

	Origin	Insertion
SHOULDER—*Continued*		
Extension—Continued Teres Major	Dorsal surface of inferior angle and lower 1/3 of axillary border of scapula.	Crest of lesser tuberosity of humerus.
Teres Minor	Upper 2/3 of dorsal surface of axillary border of scapula.	Greater tuberosity of humerus, lower part.
Infraspinatus	Medial 2/3 of infraspinous fossa of scapula	Greater tuberosity of humerus, middle part
Posterior Deltoid	See below	
Triceps Brachii (long head)	See under Elbow	
Adduction. Latissimus Dorsi Teres Major Subscapularis Pectoralis Major Teres Minor	See above	
Triceps Brachii	See under Elbow	
Abduction. Supraspinatus	Medial 2/3 of supraspinous fossa of scapula	Greater tuberosity of humerus upper part and shoulder joint capsule
Deltoid	**Anterior** anterior border upper surface lateral 1/3 of clavicle **Middle** lateral margin and upper surface of acromion **Posterior** lower lip of posterior border of spine of scapula.	Deltoid tubercle of humerus.
Internal Rotation Latissimus Dorsi Pectoralis Major Teres Major Subscapularis Anterior Deltoid	See above	
External Rotation Teres Minor Infraspinatus Posterior Deltoid	See above	

UPPER EXTREMITY AND SCAPULAR MUSCLES—*Continued*

	Origin	Insertion
	SCAPULA	
Abduction Serratus Anterior	Outer surfaces and upper borders of upper 8 or 9 ribs.	Costal surface of vertebral border of scapula
Adduction Trapezius	**Upper**: external occipital protuberance, medial 1/3 of superior nuchal line, ligamentum nuchae and spinous process of 7th cervical vertebra **Middle**: 1st through 5th thoracic vertebrae, spinous processes **Lower**: 6th through 12th thoracic vertebrae, spinous processes	**Upper**: lateral 1/3 of clavicle, acromion process **Middle**: superior lip of spine of scapula **Lower**: apex of spine of scapula
Rhomboids	**Major**: spinous processes of 2nd through 5th thoracic vertebrae **Minor**: ligamentum nuchae, spinous processes of 7th cervical and 1st thoracic vertebrae	**Major**: by fibrous attachment to vertebral border of scapula between spine and inferior angle **Minor**: vertebral border at root of spine of scapula.
Outward Rotation (inferior angle out) Serratus Anterior Trapezius	See above	
Internal Rotation (inferior angle backward) Rhomboids	See above	
Elevation Trapezius (upper) Rhomboids	See above	
Levator Scapulae	Transverse processes of first 4 cervical vertebrae	Vertebral border of scapula, medial angle and spine
Backward depression Trapezius (lower)	See above	
Forward depression Pectoralis Minor Upper fibers of Serratus Anterior (sometimes referred to as Serratus Anterior Superior)	See above	

LOWER EXTREMITY—*Continued*

	Origin	Insertion
	TOES—*Continued*	
Adduction Interossei Plantares (3)	Bases and medial sides of bodies of 3rd 4th and 5th metatarsal bones.	Medial sides of bases of proximal phalanges of same toes, and in aponeuroses of tendons of Extensor digitorum longus.
Adductor Hallucis	**Oblique head** bases of 2nd, 3rd 4th metatarsal bones, and sheath of tendon of Peroneus longus. **Transverse head:** plantar metatarso-phal. ligaments of 3rd 4th 5th toes	Lateral side of base of proximal phalanx of great toe
Abduction Interrossei Dorsales (4)	Each by 2 heads from adjacent sides of metatarsal bones.	Into extensor digitorum longus tendons and **First:** medial side of base of prox. phalanx of second toe **Other 3** into prox. phalanges, lateral sides of 2nd 3rd 4th toes.
Abductor Hallucis	Medial process of tuberosity of calcaneus.	Tibial side of base of prox phalanx of great toe
Abductor Digiti Quinti	Lateral process of tuberosity and inferior surface of calcaneous and plantar aponeurosis.	Fibular side of base of prox. phalanx of fifth toe.
	FOOT	
Inversion with dorsi flexion Tibialis Anterior	Lateral condyle and proximal 1/2 of body of tibia and interosseus membrane.	Medial and plantar surface of 1st cuneiform bone and base of 1st metatarsal bone.
Extensor Hallucis Longus	See above	
Inversion with plantar flexion Tibialis Posterior	Most of interosseus membrane middle 1/3 of posterior lateral surface of tibia and upper 2/3 medial surface of fibula	Tuberosity of navicular bone and by fibrous expansions to most of the tarsal and metatarsal bones
Flexor Hallucis Longus	See under Toes	
Flexor Digitorum Longus	See under Toes	
Eversion with dorsi flexion Peroneus Tertius	Lower 1/3 of anterior surface of fibula and interosseus membrane	Dorsal surface of base of 5th metatarsal bone.

LOWER EXTREMITY—*Continued*

	Origin	Insertion
	FOOT—*Continued*	
Eversion with dorsi flexion—Cont'd Extensor Digitorum Longus	See under Toes	
Eversion with plantar flexion Peroneus Longus	Head and upper 2/3 of lateral surface of body of fibula, and intermuscular septum	Lateral side of base of 1st metatarsal and of first cuneiform.
Peroneus Brevis	Lower 2/3 of lateral surface of body of fibula and intermuscular septum.	Tuberosity at base of 5th metatarsal bone lateral side
	ANKLE	
Dorsi flexion Tibialis Anterior Peroneus Tertius	See under Foot	
Extensor Digitorum Longus Extensor Hallucis Longus	See under Toes	
Plantar flexion. Gastrocnemius	**Medial head** posterior surface of medial condyle of femur **Lateral head** posterior surface of lateral condyle of femur	Unites with tendon of soleus and forms with it the achilles tendon which inserts into posterior surface of calcaneus.
Soleus	Posterior surface of head of fibula upper 1/3 of posterior surface of body of fibula middle 1/3 of medial border of tibia	With tendon of Gastrocnemius into posterior surface of calcaneus.
Plantaris	Lower part of linea aspera	Posterior part of calcaneus.
Tibialis Posterior Peroneus Longus Peroneus Brevis	See under Foot	
Flexor Hallucis Longus Flexor Digitorum Longus	See under Toes	
	KNEE	
Flexion Hamstrings—Outer Biceps Femoris	**Long head:** posterior part of tuberosity of ischium. **Short head:** lateral lip of linea aspera middle 2/4	Lateral side of head of fibula and slip to lateral condyle of tibia.

LOWER EXTREMITY—*Continued*

	Origin	Insertion
KNEE—*Continued*		
Flexion—Continued		
Hamstrings—Inner		
Semitendinosus	Tuberosity of ischium	Upper part of antero-medial surface of body of tibia
Semimembranosus	Tuberosity of ischium	Postero-medial aspect of medial condyle of tibia.
Popliteus	Anterior part of groove on lateral condyle of femur and popliteal ligament.	Above popliteal line of tibia.
Gracilis	See under Hip adductors	
Sartorius	Anterior superior iliac spine and upper 1/2 of notch below	Upper part of medial surface of body of tibia.
Gastrocnemius Plantaris	See under Ankle	
Extension		
Quadriceps Femoris		The four parts of the quadriceps
Rectus Femoris	**Anterior head** anterior inferior iliac spine **Posterior head** groove above rim of acetabulum.	Into quadriceps tendon which through the patellar ligament inserts into the tuberosity of the tibia
Vastus Lateralis	Upper part of intertrochanteric line anterior and inferior borders of greater trochanter lateral lip of gluteal tuberosity upper 1/2 of lateral lip of linea aspera.	
Vastus Medialis	Medial lip of linea aspera and upper part of medial supra condylar line	
Vastus Intermedius	Anterior and lateral surfaces of body of femur upper 2/3	
Assisted by Tensor Fasciae Latae	Anterior part of outer lip of iliac crest outer surface of anterior *superior* spine deep surface of fascia lata	Into iliotibial band at junction of upper and middle thirds of thigh

LOWER EXTREMITY—*Continued*

	Origin	Insertion
	HIP	
Flexion		
Iliacus	Upper 2/3 of iliac fossa, inner lip of iliac crest, base of sacrum	Lateral side of tendon of Psoas major and just below lesser trochanter
Psoas Major	Anterior surfaces, processes of all lumbar vertebrae, sides of bodies of last thoracic and all lumbar vertebrae and corresponding intervertebral discs.	Lesser trochanter of femur
Sartorius Tensor Fascia Lata Rectus Femoris Pectineus Adductors	} See above } See below	
Extension		
Gluteus Maximus	Outer surface of ilium behind posterior gluteal line, posterior surface of lower part of sacrum, side of coccyx, sacrotuberous ligament, lumbo-dorsal fascia.	Iliotibial band of fascia lata, gluteal tuberosity of femur
Hamstrings	See under Knee	
Assisted by Gluteus Medius Piriformis	See below	
Adduction		
Adductor Magnus	Inferior rami of pubis and ischium, tuberosity of ischium.	Linea aspera, and adductor tubercle of medial condyle of femur
Adductor Longus	Anterior surface of pubis at junction of crest and symphysis	Middle 1/3 of linea aspera.
Adductor Brevis	Outer surfaces of superior and inferior rami of pubis	Upper part of linea aspera.
Gracilis	Inferior rami of pubis and ischium.	Upper part of medial surface of body of tibia, below condyle
Pectineus	Superior ramus of pubis	Femoral pectineal line

LOWER EXTREMITY—*Continued*

	Origin	Insertion
	HIP—*Continued*	
Adduction.—Continued		
Assisted by		
Gluteus maximus (lower fibers)	See above	
Quadratus Femoris	See below	
Inner Hamstring	See above	
Abduction		
Gluteus Medius	Outer surface of ilium between iliac crest and posterior gluteal line above and anterior gluteal line below	Oblique ridge on lateral surface of greater trochanter
Gluteus Minimus	Outer surface of ilium between anterior and inferior gluteal lines and margin of greater sciatic notch.	Anterior border of greater trochanter and hip joint capsule
Tensor Fascia Lata Sartorius	See under Knee	
Assisted by		
Piriformis	See below	
Gluteus Maximus (upper fibers)	See above	
Internal Rotation		
Tensor Fascia Lata	See under Knee	
Gluteus minimus Gluteus Medius (anterior part)	See above	
Inner Hamstrings Gracilis	See under Knee	
External Rotation		
Piriformis	Anterior surface of sacrum between 1 2 3 4 sacral foramina.	Upper border of greater trochanter
Quadratus Femoris	Upper part of external border of tuberosity of ischium.	Upper part of linea quadrata extending downward from intertrochanteric crest.
Obturator Internus	Inner surface of antero-lateral wall of pelvis and obturator membrane	Medial surface of greater trochanter

LOWER EXTREMITY—*Concluded*

	Origin	Insertion
	HIP—*Continued*	
External Rotation—Continued Obturator Externus	Rami of pubis inferior ramus of ischium and obturator membrane	Trochanteric fossa of femur
Gamellus Superior	Outer surface of spine of ischium	With tendon of Obturator internus into medial surface of greater trochanter
Gamellus Inferior	Upper part of tuberosity of ischium	With tendon of Obturator internus into medial surface of greater trochanter
Iliopsoas Gluteus Medius (posterior fibers) Gluteus Maximus Adductors	See above	
Outer Hamstrings Sartorius	See under Knee	

BACK

	Origin	Insertion
Quadratus Lumborum	Iliolumbar ligament iliac crest. Occasionally from upper borders of transverse processes of lower 3 or 4 lumbar vertebrae.	Lower borders of last rib and transverse processes of upper 4 lumbar vertebrae
Erector Spinae or Sacrospinalis Group	Common Origin Anterior surface of a broad tendon attached to medial crest of sacrum spinous processes of lumbar and 11th and 12th thoracic vertebrae inner lip of iliac crest and lateral crests of sacrum Additional origins listed below	
Iliocostalis Lumborum		Inferior borders of angles of lower 6 or 7 ribs.
Iliocostalis Dorsi	By tendons from upper borders of angles of lower 6 ribs.	Upper borders of angles of upper 6 ribs, and back of transverse process of 7th cervical vertebra.
Iliocostalis Cervicis	Angles of 3rd 4th, 5th and 6th ribs.	Posterior tubercles of transverse processes of 4th, 5th and 6th cervical vertebrae
Longissimus Dorsi	In lumbar region it is blended with iliocostalis lumborum posterior surfaces of transverse and accessory processes of lumbar vertebrae anterior layer of lumbodorsal fascia.	Transverse processes of all thoracic vertebrae and lower 9 or 10 ribs between tubercles and angles
Longissimus Cervicis	By tendons from transverse processes of upper 4 or 5 thoracic vertebrae	By tendons into posterior tubercles of transverse processes of 2nd through 6th cervical vertebrae.
Longissimus Capitis	By tendons from transverse processes of upper 4 or 5 thoracic vertebrae and articular processes of lower 3 or 4 cervical vertebrae	Posterior margin of mastoid process.
Spinalis Dorsi	By tendons from spinous processes of first 2 lumbar and last 2 thoracic vertebrae	Spinous processes of 4–8 (variable) thoracic vertebrae
Spinalis Cervicis	Ligamentum nuchae lower part spinous process 7th cervical	Spinous processes cervical 6th and 7th thoracic 1 to 4

BACK—*Continued*

	Origin	Insertion
Spinalis Capitis	Inseparably connected with Semispinalis capitis	
Semispinalis Dorsi	Transverse processes of 6th to 10th thoracic vertebrae	Spinous processes of upper 4 thoracic and lower 2 cervical vertebrae
Semispinalis Cervicis	Transverse processes of upper 5 or 6 thoracic vertebrae	Cervical spinous processes 2nd through 5th
Semispinalis Capitis	Transverse processes of upper 6 or 7 thoracic and 7th cervical vertebrae and articular processes of cervical 4th 5th and 6th.	Between superior and inferior nuchal lines of occipital bone
Multifidus	Sacral region back of sacrum medial surface of posterior superior iliac spine Lumbar region all transverse processes Thoracic region all transverse processes Cervical region articular processes of lower 4 vertebrae	Whole length of spinous process of a vertebra above
Rotatores (11)	Upper and back part of transverse processes of thoracic vertebrae	Lower border and lateral surface of lamina of the vertebra above
Interspinales	Placed in pairs between spinous processes of contiguous vertebrae Cervical 6 pairs Thoracic 2 or 3 pairs Lumbar 4 pairs	(See Origin)
Intertransversarii	Small muscles placed between transverse process of vertebrae in cervical thoracic and lumbar regions.	(See Origin)

Abdominals
(see pages 184 to 187)

NECK

	Origin	Insertion
Flexion Longus Colli	**Superior oblique portion:** Anterior tubercles of transverse processes of 3rd, 4th, 5th cervical vertebrae	Tubercle on anterior arch of atlas.
	Inferior oblique portion Anterior surface of bodies of first 2 or 3 thoracic vertebrae	Anterior tubercles of transverse processes of 5th and 6th cervical vertebrae
	Vertical portion Anterior surface of bodies of upper 3 thoracic and lower 3 cervical vert brae	Anterior surface of bodies of 2nd 3rd, 4th cervical vertebrae
Longus Capitis	Anterior tubercles of transverse processes of 3rd through 6th cervical vertebrae.	Inferior surface of basilar part of occipital bone.
Sterno-cleido-mastoid	**Medial or sternal head** Upper part of manubrium **Lateral or clavicular head** medial 1/3 of clavicle	Lateral surface of mastoid lateral 1/2 of superior nuchal line of occipital bone
Scalenus Anterior	Anterior tubercles of transverse processes of 3rd through 6th cervical vertebrae	Scalene tubercle and upper ridge of 1st rib
Rectus Capitis Anterior	Root of transverse process, and anterior surface of atlas	Inferior surface of basilar part of occipital bone
Platysma	Fascia covering upper parts of pectoralis major and deltoid.	Inferior margin of mandible, and skin of lower part of cheek and corner of mouth
Extension Upper trapezius	See under Shoulder	
Semispinalis Capitis Semispinalis Cervicis Longissimus Capitis Longissimus Cervicis Iliocostalis Cervicis Cervical part of Multifidus and Interspinales	See under Back	
Splenius Capitis	Lower 1/2 of ligamentum nuchae spinous process of 7th cervical vertebrae spinous processes of upper 3 or 4 thoracic vertebrae	Mastoid process of temporal bone and on occipital bone below lateral 1/3 of superior nuchal line.

NECK—*Continued*

	Origin	Insertion
Extension.—Continued Splenius Cervicis	Spinous processes of 3rd to 6th thoracic vertebrae	Transverse processes of upper 2 or 3 cervical vertebrae
Rectus Capitis Posterior Major	Spinous process of axis.	Lateral part of inferior nuchal line of occipital bone
Rectus Capitis Posterior Minor	Tubercle on posterior arch of atlas.	Medial part of inferior nuchal line of occipital bone
Obliquus Capitis Inferior	Apex of spinous process of axis.	Posterior part of transverse process of atlas
Obliquus Capitis Superior	Upper surface of transverse process of atlas.	Between superior and inferior nuchal lines of occipital bone
Lateral Flexion. (one side acting alone) Trapezius (upper)	See under Shoulder	
Scalenus Anterior	See above	
Scalenus Medius	Posterior tubercles of transverse processes of 2nd through 7th cervical vertebrae.	Upper surface of 1st rib between tubercle and subclavian groove
Scalenus Posterior	By 2 or 3 tendons from posterior tubercles of transverse processes of lower 2 or 3 cervical vertebrae.	Outer surface of 2nd rib
Rectus Capitis Lateralis	Upper surface of transverse process of atlas.	Under surface of jugular process of occipital bone
Sterno-cleido-mastoid Longus Colli Splenius Cervicis Splenius Capitis Obliquus Capitis Superior	See above	
Iliocostalis Cervicis Longissimus Capitis Longissimus Cervicis Semispinalis Capitis Intertransversarii	See under Back	

NECK—*Continued*

	Origin	Insertion
Rotation		
Sternocleidomastoid		
Scaleni		
Anterior		
Medius		
Posterior		
Longus Colli		
Longus Capitis	See above	
Splenius Cervicis		
Splenius Capitis		
Rectus Capitis Posterior Major		
Obliquus Capitis Inferior		
Rectus Capitis Anterior		
Longissimus Capitis		
Multifidus	See under Back	
Semispinalis Capitis		
Rotatores		

HEAD

	Origin	Insertion
SCALP AND FOREHEAD		
Epicranius Occipitalis	Lateral 2/3 of superior nuchal line of occipital bone and mastoid part of temporal.	Galea aponeurotica.
Frontalis	**Medial fibers** continuous with those of the Procerus **Intermediate fibers** blend with the Corrugator and Orbicularis oculi **Lateral fibers:** blend with Orbicularis oculi over zygomatic process of frontal bone	Join galea aponeurotica below coronal suture
EYELID		
Levator Palpebrae Superioris	Under surface of small wing of sphenoid	**Superficial lamella:** palpebral part of Orbicularis oculi and deep surface of skin of upper eyelid **Middle lamella** upper margin of superior tarsus **Deep lamella:** superior fornix of conjunctiva.
Orbicularis Oculi	Nasal part of frontal bone frontal process of maxilla anterior surface of medial palpebral ligament	Surrounds the circumference of the orbit spreads over temple and downward on cheek and blends with adjacent muscular or ligamentous structure
Corrugator	Medial end of superciliary arch.	Deep surface of skin above middle of orbital arch.
EYE		
Recti Superior Inferior Medialis Lateralis	From fibrous ring which surrounds upper medial and lower margins of optic foramen	Into sclera.
Obliquus Oculi Superior	Above margin of optic foramen.	Into sclera.
Obliquus Oculi Inferior	Orbital surface of maxilla	Into sclera

HEAD—*Continued*

	Origin	Insertion
NOSE		
Procerus	Fascia covering lower part of nasal bone and upper part of lateral nasal cartilage	Into skin over lower part of forehead between eyebrows
Nasalis	**Transverse part** above and lateral to incisive fossa of maxilla **Alar part** greater alar cartilage	With aponeurosis of Procerus Integument at point of nose.
Depressor Septi	Incisive fossa of maxilla	Into septum and back part of ala of nose.
Dilatator Naris Posterior	Margin of nasal notch of maxilla, and lesser alar cartilages.	Skin near margin of nostril.
Dilatator Naris Anterior	Greater alar cartilage	Integument near margin of nostril
MOUTH		
Quadratus Labii Superioris	**Angular head** upper part of frontal process of maxilla **Infra-orbital head** lower margin of orbit **Zygomatic head** malar surface of zygomatic bone	Greater alar cartilage and skin of nose and lateral part of upper lip Muscular substance of upper lip Upper lip.
Caninus	Canine fossa	Angle of mouth, blending with adjacent muscles.
Zygomaticus	Zygomatic bone	Angle of mouth, blending with adjacent muscles.
Mentalis	Incisive fossa of mandible	Integument of chin.
Quadratus Labii Inferioris	Oblique line of mandible	Integument of lower lip blending with adjacent muscles.
Triangularis	Oblique line of mandible	Angle of mouth blending with adjacent muscles.
Buccinator	Outer surfaces of alveolar processes of maxilla and mandible and anterior border of pterygomandibular tendinous band	Angle of mouth blending with Orbicularis oris.

HEAD—*Continued*

	Origin	Insertion
	MOUTH—*Continued*	
Orbicularis Oris	Numerous strata of muscular fibers surrounding the orifice of the mouth derived in part from other facial muscles.	For most part to external skin and mucous membrane
Risorius	Fascia over Masseter	Into skin at angle of mouth
Masseter	**Superficial portion** zygomatic process of maxilla, and anterior 2/3 of zygomatic arch **Deep portion** posterior 1/3 of lower border and medial surface of zygomatic arch.	Angle and lower 1/2 of lateral surface of ramus of mandible Upper 1/2 of ramus and lateral surface of coronoid process of mandible
Temporalis	Temporal fossa and fascia	Coronoid process and anterior border of ramus of mandible
Pterygoideus Externus	**Upper head** lateral surface great wing of sphenoid, and infra temporal crest **Lower head** lateral surface of lateral pterygoid plate	Depression in front of neck of condyle of mandible front margin of articular disk of tempero-mandibular articulation
Pterygoideus Internus	Medial surface of lateral pterygoid plate and pyramidal process of palatine bone and tuberosity of maxilla	Lower and back part of medial surface of ramus and angle of mandible
	EAR	
Auricularis Anterior	Lateral edge of galea aponeurotica	Projection in front of helix.
Auricularis Superior	Galea aponeurotica.	Upper part of cranial surface of auricula.
Auricularis Posterior	Mastoid portion of temporal bone	Lower part of cranial surface of concha
	SUPRAHYOID MUSCLES	
Digastric	**Posterior belly** mastoid notch of temporal bone **Anterior belly** lower border of mandible	By suprahyoid aponeurosis into hyoid bone
Stylohyoideus	Back and lateral surface of styloid process of temporal bone	Hyoid bone

HEAD—*Concluded*

	Origin	Insertion
	SUPRAHYOID MUSCLES—*Continued*	
Mylohyoideus	Length of mylohyoid line of mandible	Hyoid bone
Geniohyoideus	Inferior mental spine of mandible	Hyoid bone.
	INFRAHYOID MUSCLES	
Sternohyoideus	Posterior surface of medial end of clavicle and upper part of manubrium.	Lower border hyoid bone
Sternothyroideus	Posterior surface of manubrium edge of cartilage of first rib.	Oblique line of lamina of thyroid cartilage.
Thyreohyoideus	Oblique line on lamina of thyroid cartilage	Lower border hyoid bone
Omohyoideus	Upper border of scapula.	Lower border hyoid bone.

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